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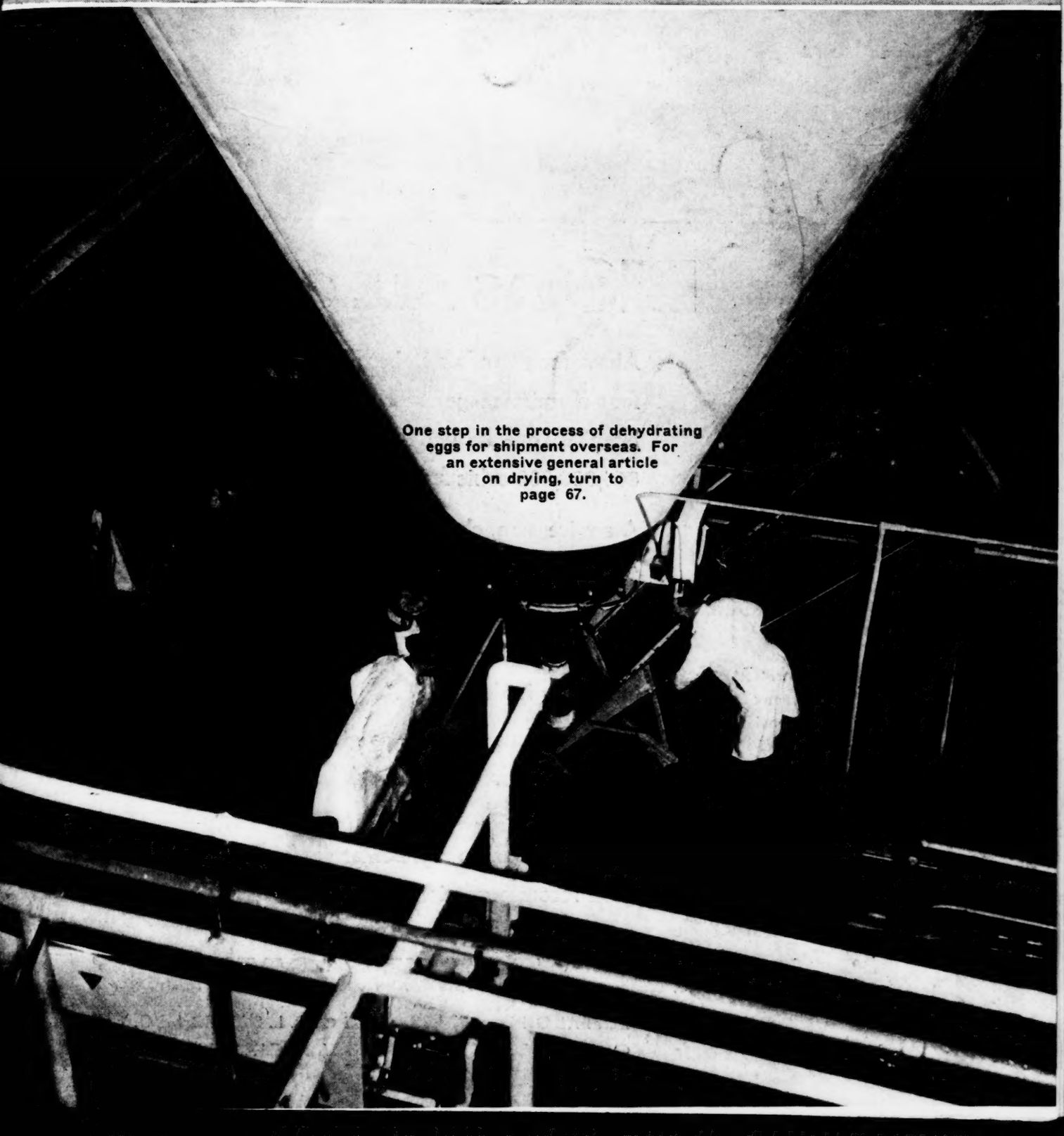

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A Simplified Method for

Radiant Heating Panel Calculations

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THE following procedure for calculating heating panel requirements is an endeavor to reduce the work required and at the same time offer a reasonably accurate and practical method of quickly and easily arriving at the amount of surface and its temperature required for a given set of conditions. Certain assumptions and approximations are made and the justification for these will be offered.

First, let us consider briefly the basis of heat transfer by radiation because this seems generally less understood than heat transfer by convectional currents. If one object is warmer than another, heat will be sent from the warm object to the cooler one if the warm object can "see" the cooler one. It doesn't matter if the cooler object is above, below, or to one side of the warm object, as long as straight line rays from one can impinge on the other. Certain of the radiant rays get absorbed by the cooler object and certain of them are reflected back to the original object or to other objects. Rays that are absorbed go toward raising the temperature of the original cool object and this object itself radiates heat to cooler objects.

For practical purposes we must have a little knowledge as to how to calculate this radiant heat flow. These are the things that affect radiant heat transfer, considering the matter practically and from a building heating standpoint only: Difference in temperature, amount of surface involved, and surface characteristics. This simplification, we emphasize, is only for practical considerations, and it would be deemed incomplete from an academic position.

Expressing this mathematically so as to actually evaluate the amount of heat transferred, we have

$$Q_r/A = 0.172\ (10^{-8})\ (ep{\cdot}es)\ (Tp^4 — Ts^4)$$

We say that the total heat transferred per sq ft in an hour equals a constant (0.172) (10^{-8}), multiplied by the difference of the fourth powers of the absolute temperature of the surfaces, and this is multiplied by the product of the surface radiating characteristics usually denoted by e and called "emissivity".

Since e or emissivity of the relatively cool walls changes if a curtain is drawn or if surfaces are redecorated, there is no practical point in attempting to achieve an exact value for e. Fortunately, as will be shown, any variance of conditions within normal expectations can be overcome by a small change in heating medium temperature.

If we consider the various factors affecting the heating of a room in order, and the degree in which they vary, except in extraordinary cases, we can see the effect of error accumulating in any one direction.

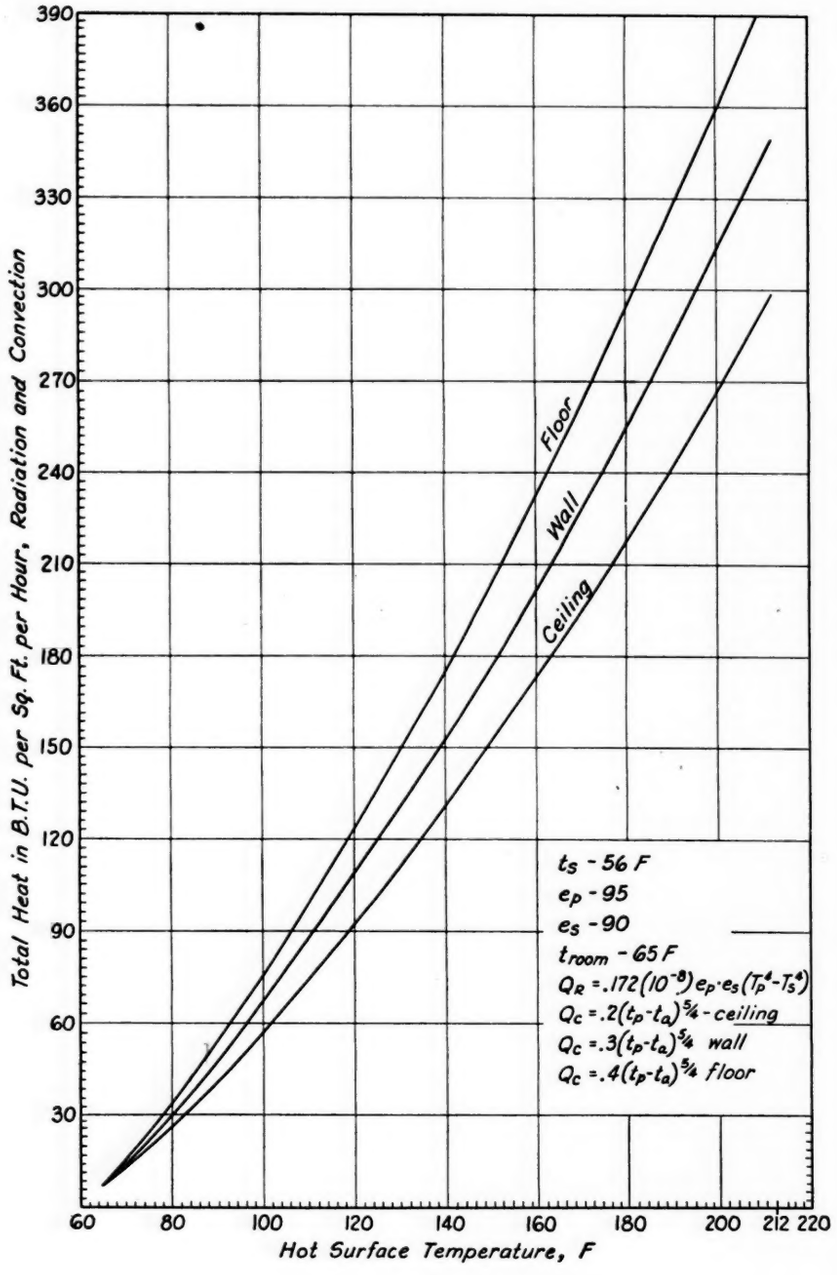


Chart for Simplified Calculations

Let us consider the average wall temperature, which is one of the determinates of heat emission. A large number of conventionally constructed buildings were examined with various assumptions being made on the degree of window-curtaining and double glazing and with heat transmission coefficients varying from U = 0.3 to U = 0.1. It was found that considering an average inside temperature of 65F and with outside temperature ranges of from —20F to 20F, the average inside surface temperature exclusive of the heating panel is within 4F of 55F. In the case of —20F outside temperature, single glass with no shading and an exposure to the weather of 50% of the room surface exclusive of heating panel, the average surface temperature was 52F. This average surface temperature increased to 57F when the proportion of weather exposed surfaces to interior areas was decreased to 20% and calculations were based on storm windows and a U factor of 0.1.

Calculations based on zero degree F outside temperatures affected the average surface temperature less than one degree. Similar calculations based on a 20F outside temperature yielded a range from 55 to 59F.

Since in relatively cold sections, —20F, there will be a tendency toward better insulated walls and double glazing, and in milder climates of 20F there is a tendency not to have these things, it is reasonable to assume an average wall surface temperature of about 56F. If an average wall temperature for all surfaces exclusive of the heating area is assumed at 56F, the highest probable error in surface temperature would be 3F. This we would say should be treated as a maximum, the probable error being less than 1F. In the range of wall temperatures from 50 to 65F, a mistake of 1F yields an error of about .75 Btu per sq ft per hour if all other conditions remain the same. The warmer the surface temperature, the less heat is absorbed by it from the heating panel.

In addition to the wall surface temperature, the emissivity factor e for these walls must be examined. The accurate determination of this e is difficult when we are offered a range of about 0.05 for most surfaces. A common finish in the range used is offered at 0.90 to 0.95. The dwellings examined indicated that an assumption of 0.90 for e would probably never yield an error exceeding 0.03. The higher e is, the more heat will be received by this surface from the heating panel and each 0.01 will cause a variance of approximately 1.2 Btu per sq ft per hour.

We must also consider the room temperature since this influences the amount of heat given off by the heating panel by convection. Within the range of room temperatures of 50 to 70F an error of 1F in assumed room temperature yields an error in heat given off of 0.75 Btu per sq ft per hour when the ceiling is the source of heat. When floors are the heating source the possible error due to room temperature is doubled but the calculation of floor heating panels is practically a guessing game anyway when it is considered that the type, location, color and insulating qualities of floor coverings for dwellings are seldom known at the heating design stage, and the designer must allow for eventual change in the floor covering. Floor panels must then be quite conservatively designed for peak conditions. With wall heating panels, the problem is somewhat similar

to floors although not as bad and an error here in estimating room temperatures brings about an error of about 1.2 Btu per sq ft per hour.

We have not thus far discussed the heating panel itself. Characteristics of this panel are the ones that must stay under control. This heating panel is obviously the heating engineer's province and his design can determine very closely its effect on a room. Window and floor coverings and wall decoration are things that we cannot continuously control, but if we examine the maximum probable error due to accumulative incorrect assumptions, we will find that a slight variation of heating medium temperature can compensate for normal error due to wrongly assumed room conditions.

Let us take for example a condition where we have assumed the average surface temperature, exclusive of the heating surface, at 3F too high; the *e* at 0.03 less than it is, and the air temperature 3F too high. With a ceiling heating panel these assumptions would give an error of

$$[3\ (.75) + 3\ (1.2) + 3\ (.75)] = \text{about 8 Btu per sq ft per hour.}$$

This accumulative error could be completely compensated for by an increase in panel temperature of approximately 5F. It should be recognized that this is actually an extreme condition with all error being in one direction and at a probable extreme. Actually a condition as outlined would probably never develop, as the higher surface temperature and air temperature would indicate a heat requirement somewhat less than that for which the system was designed, and comfort conditions would prevail without the room being given the amount of heat originally calculated. Since the surface temperature of the heating panel must be varied automatically to suit comfort conditions, it is only on peak design days that we are concerned with the maximum temperature of the heating panel.

It is highly probable that the accumulative condition taken would practically never occur and that conservative designers would have left themselves the required leeway. It is quite possible that an extensive investigation may indicate that the *e* factor for ordinary conditions may be found to vary less than the range here assumed which would reduce sharply the possible error. As a matter of fact it could be reasonably argued that the use of an average emissivity introduces no error not now existing in suggested methods of calculation due to the range of *e* offered for any surface. What figure does the designer select when *e* is offered to him as 0.90 to 0.95? And what about window draping?

The foregoing discussion leads us to a practical method of selecting heating panels without requiring any more information than the heat loss under design conditions and an understanding that we are not dealing with radically decorated rooms.

Assuming conditions as described in this article, the accompanying graph was drawn using the following equations:

$$\text{Convection from ceiling} = Q_c = .2\ (t_p - t_a)^{5/4}$$
$$\text{wall} = Q_c = .3\ (t_p - t_a)^{5/4}$$
$$\text{floor} = Q_c = .4\ (t_p - t_a)^{5/4}$$
$$\text{Radiation} = Q_r = .172\ (10^{-8})\ (e_p \cdot e_s)\ (T_p^4 - T_s^4)$$
$$\text{Total heat} = Qh + Qr$$

The following abbreviations are used in these formulas:

Q_c = Heat yielded by convection
Q_r = Heat yielded by radiation
t_p = Heating panel temp. —°F
t_a = Room air temp. °F
T_p = Heating panel temp. F° Abs.
T_s = Wall surface temp. F° Abs.
e_p = Emissivity of heating panel
e_s = Emissivity of wall surface

It should be noted that heat radiated from the relatively hot panel is a function of its emissivity and the wall surface emissivity. If both emissivities are not considered simultaneously, a considerable error results.

One method of calculation suggested subtracts the total radiation emitted by the cool wall from that emitted by the hot panel, considering respectively the temperatures and emissivity of each.

This method does not jibe with fundamental radiant theory as expressed by

$$P_r = KA\ Fa\ Fe\ (T_1^4 - T^4)$$

where K is the Stefan-Boltzmann radiation constant, A is the unit area, Fa is the configuration factor which we can assume as l, and Fe is the emissivity factor. Fe may only be considered equal to e for a small body in a large enclosure. In the cases of ordinary panel Fe may be more exactly taken as $(e_p) \cdot (e_s)$.

Thus for a heating panel with an *e* of 0.95 and an average other room surface *e* of 0.90, Fe becomes approximately .86. The use of 0.86 for heating and heated surfaces gives an entirely different result from that obtained by using 0.95 for the heating panel and subtracting from it the heated surfaces using an *e* of 0.90. This latter method neglects the fact that in our problem there is receptivity as well as emissivity.

Using the accompanying graph, it is only necessary to compute the heat loss of an area and select a tentative location of the heating panel. For a given surface temperature, the total amount of heat given to the room is easily ascertained.

It may be held the method of total heat emitted does not offer an opportunity to evaluate the proportions of radiant and convected heat, but from a practical viewpoint only minor changes in proportion of radiant heat emission can be achieved within the conventionally used ranges. When this is considered in the light of late investigations which state that comfort is a function of air temperature and radiant effect, it loses some importance.

There is no need or justification for the selection of heating surface characteristics to be any more complicated than selecting a radiator for a given heat loss.

What the Ventilating Engineer Should Know About Methyl Bromide

The accompanying article is abstracted from a review of the subject of methyl bromide poisoning prepared by Harry Heimann, M.D., Division of Industrial Hygiene, New York State Department of Labor, and originally presented in the Department's "The Industrial Bulletin."

METHYL bromide (CH_2Br) is a non-inflammable, colorless liquid or gas with a density of 1.732 at 0C, a melting point of —93C, a boiling point of 4.6C and a vapor tension of 1250 mm at 20C. It is soluble in alcohol, ether, chloroform, carbon disulfide and benzol, but slightly soluble in water in which it forms a voluminous crystalline hydrate. Methyl bromide has a burning taste, a chloroform-like odor in higher concentrations, but is odorless in the lower concentrations which are, however, dangerous if inhaled.

Methyl bromide is synthesized by the interaction of methyl alcohol and bromine in the presence of phosphorus. It is used in organic synthesis, as in the manufacture of antipyrene, and finds use as a refrigerant, a fire-extinguisher, and as an insecticide.

The toxicity of methyl bromides has been known for many years. The first case of industrial poisoning was reported in 1899 by Schuler, although previous reports had indicated dangers of its inhalation as an anesthetic. Schuler's report was followed by many others, most of them from Europe. Besides Watrous' recent report of mild poisoning there have appeared in the medical literature 15 fatal cases. It is apparent from this literature that the clinical entity, methyl bromide poisoning, can be divided into three phases. Interpreting broadly, Floret has described these as the prodromal, excitement and recovery states.

In the prodromal stage the subject complains of symptoms of inebriation; Dizziness, nausea, vomiting and weakness, shortly after the exposure. It is unusual for the patients not to have these early symptoms. After a period of some hours, but which may extend to even 10 days, the excitement stage sets in. During this period there are generalized or localized epileptiform convulsions, muscular tremors, maniacal symptoms and muscular spasms.

If the patient survives the second stage there follows a long period of convalescence which may last a year or longer, although most cases get entirely well much sooner. During this period the frequency of the convulsive seizures gradually decreases, until they cease entirely.

Animal experiments, in which methyl bromide was given either by inhalation or ingestion, in general, confirmed the findings noted in the accidental poisonings of humans. Flury and Zernik found that exposure to 900 ppm was not fatal to dogs, whereas an exposure of 9000 ppm for one hour was fatal. Their concentrations of methyl bromide in the reported human exposures were in some instances of low intensity and in a smaller number of instances were high. However, figures for such concentrations have not been available until Watrous' recent report. In his report the air concentrations were probably below 35 ppm with some rises above that level for very short periods; yet mild toxic symptoms developed among 33 of the 90 workers exposed. The symptoms in these instances were generally mild and consisted of headache, nausea, vomiting, and loss of appetite.

Of five cases analyzed, one who had the biggest exposure died in coma following convulsions; one had mild mental symptoms; two had eye symptoms, and one had no symptoms. The finding of enlarged livers in two cases is presented, but the significance of this finding is not clear, since it is not known if such a condition anteceded the exposure to methyl bromide.

One of the cases involved a worker who sealed methyl bromide in ampoules by use of a gas flame. The filling of glass ampoules with a chemical which is a gas at normal temperatures and pressures, requires an elaborate system of piping to keep the material in a liquid state. The primitive nature of the apparatus at the plant in question could not but produce an extremely hazardous situation for the workers. Failure to supply an adequate exhaust hood added materially to this hazard. As a result, the employee who worked at the outlet of the methyl bromide, and whose exposure was therefore greatest, developed the most serious poisoning. The others, exposed to lesser amounts, suffered proportionately less damage.

Installation of an adequate cooling apparatus and exhaust hoods resulted in the elimination of the hazard. Air tests made after this installation revealed the absence of any halide in the air of the workroom.

Summary and Conclusions

1—A methyl bromide ampoule-filling plant, operating with inadequate control apparatus, resulted in producing cases of poisoning.

2—The cases of poisoning are described and the post-mortem findings in the fatal case are presented.

3—Engineering control, essentially by the use of adequate cooling systems, resulted in elimination of the hazard.

A Material for Industry

GLASS PIPING

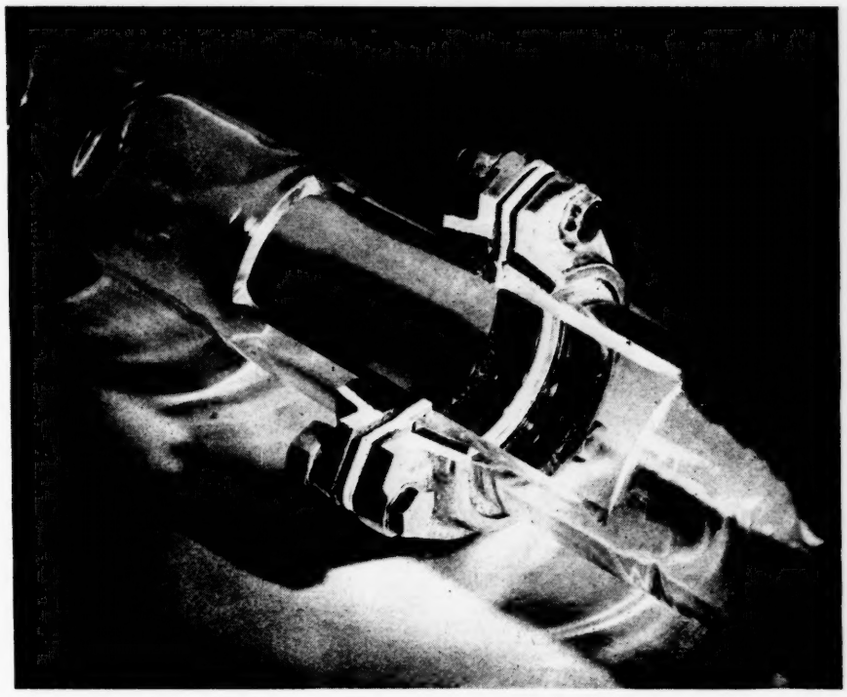


Fig. 1. Cutaway view of a glass pipe joint showing flanges, asbestos inserts and the interface gasket.

GLASS piping has been used with good results in the chemical field because the pipe has the ability to resist corrosion, has good thermal properties and mechanical strength, and is easy to keep clean. The properties of this pipe and how it can be installed are still unfamiliar to most engineers, and for that reason it is presented as a "material for industry."

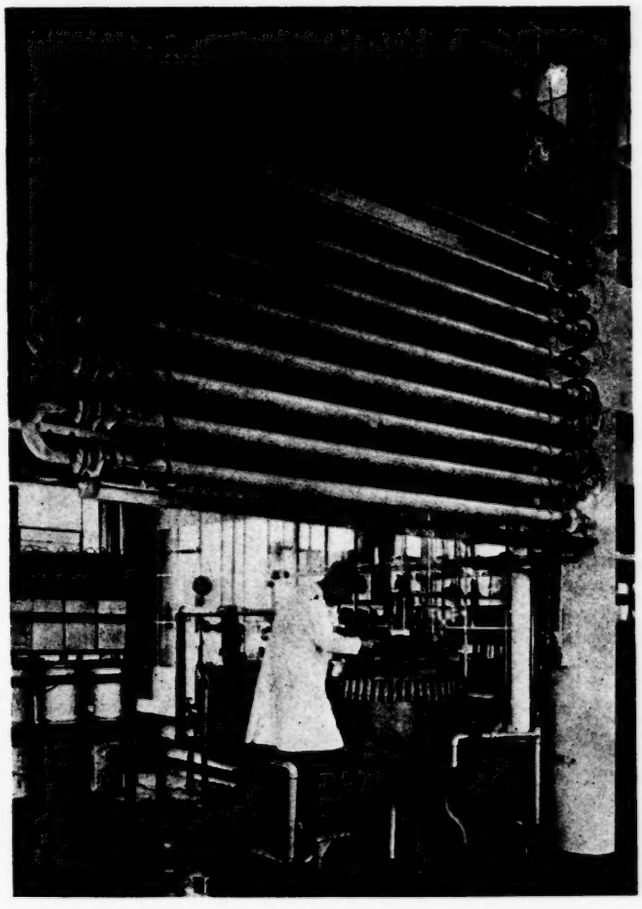


Fig. 2. Pyrex heat exchanger used in condensing organic vapors.

The pipe is not made from the common window glass or material used for bottles such as lime glass, but it is made from borosilicate composition which is superior to the other variety. It has a very low coefficient of expansion so that it can withstand instantaneous temperature changes. For all practical purposes, the pipe can be considered as being impervious to acids except hydrofluoric and hot concentrated phosphoric acid.

At first, there was some aversion to its use because engineers believed it was not strong enough to withstand everyday industrial use. Yet today glass pipe is being used in vital ordnance plants where a failure of a glass pipe line would cause a plant shutdown.

The type of glass pipe used at the present time is illustrated in Fig. 1. Each fitting or length of pipe has a conical or tapered end which matches the taper of the metal companion flanges. These are bolted together to make a compression-type joint. An asbestos composition strip is inserted between the metal flanges and the glass to act as a cushion. Between the pipe faces a ⅛ in. thick resilient gasket is used.

This is the only material other than glass which comes in contact with the fluid being conveyed. Elbows, tees, reducers, Y's and U-bends are available in sizes of 1, 1½, 2, 3 and 4 in. actual inside diameter. Pipes are made to length at the factory with the conical ends sealed on. Any length can be obtained from about 6 to 10 ft with wall thicknesses of 5/32 to ¼ in. depending on the diameter. Adaptors are available to connect the Pyrex glass pipe to any other type.

Pyrex pipe can safely withstand steady nonpulsating internal liquid pressures up to 100 lb per sq in. When gases or vapors are to be placed under

pressure in glass equipment it is a safe practice to provide some protection to prevent damage to property or injury to personnel in the event of some freak type of failure.

The glass itself will not be harmed on continuous heating up to 900F. However, the interface joint gaskets usually show signs of deterioration at sustained temperatures above 275F although there are installations where temperatures as high as 500F are reached. The glass should not be subjected to instantaneous temperature changes in excess of 200F.

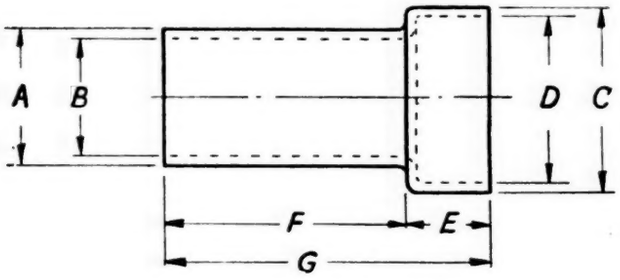


TABLE I.—DETAILS OF BELL AND SPIGOT PIPE

Nominal Size, Inches	A Inches	B Inches	C Inches	D Inches	E Inches	F Inches	G Inches
6½	6½	6	8⅝	8⅛	3	33	36
9	9⅛	8½	11½	10⅞	3	39	42
12	12	11⅜	14⅛	13½	3	27	30
16	16	15⅝	18	17⅜	3	24	27
18	18	17⅜	20	19⅜	3	21	24

Glass pipe is easy to install. It is not necessary to put a steamfitter on the job since the pipes come from the factory cut to the correct length. All that is necessary when ordering the pipe is a sketch showing the center to center dimensions.

In general, the rules for good pipe layout practice are about the same for glass as for any other material although it may be advisable to modify the procedure with glass in some instances. Any conventional type of hanger may be used if a strip of rubber, asbestos or friction tape or some such material is used to prevent the metal from scratching the glass. Temporary hangers may be made of rope or baling wire while pipes are being assembled and then replaced with the permanent types when accurate measurements can be obtained. Below is a table that indicates the allowable span between hangers for horizontal pipes.

Pipe Size	Maximum Unsupported Span in Ft. Air or Gas	Water	H_2SO_4 (Sp. Gr. 1.83)
1.....	10	10	7
1½.....	10	10	8
2.....	11	11	9
3.....	12	12	10
4.....	15	15	12

Short vertical lines up to about 30 ft long can be supported by one or two pairs of clamps lined with ⅛ to ¼ in. thick rubber or similar material. Longer lines should be held by clamps suspended by coil springs to insure uniform load distribution.

Valves and other heavy objects should not be supported on the pipes themselves. The best place to put a valve is on a tank so that no torque will be exerted on the glass when it is tightly closed. If this is not possible, the valve should be mounted independently of the pipe system.

Expansion joints are rarely required. Glass pipe expands only about one-third as much as steel and about one-sixth as much as brass—a 100 ft length of glass pipe will expand only about ¼ in. on a 100F temperature increase.

Usually a 45° or 90° bend will absorb the expansion satisfactorily since the resilient interface joint gasket will yield somewhat under stress. Depending on the pipe size and the gasket used, a 10 ft length of pipe on a 90° bend may be deflected from ½ to 1¼ in. which is usually enough to absorb all the thermal expansion.

Precautions should be taken to prevent stresses in the pipe caused by water-hammer. When glass pipe is used at the discharge end of a high velocity centrifugal pump, the first one or two bends in the line should be rigidly braced or else the line will sway violently when the pump is started. In fact, wherever there are two bends in series in a line carrying high velocity fluids, rigid clamps should be used to eliminate side sway. Glass lines connected to reciprocating piston pumps should also be braced at one or more points to prevent establishment of a series of severe vibrations at some frequency sympathetic to that of the pump.

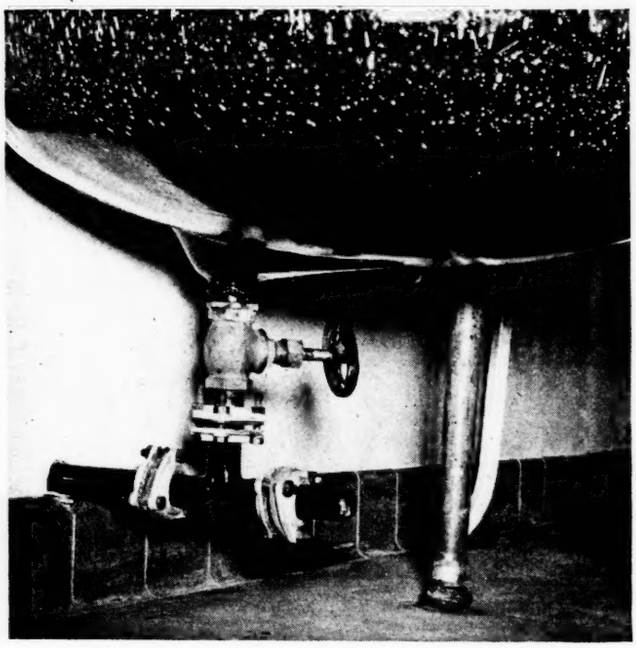


Fig. 3. Preferred method of mounting valve in glass pipe line. Valve is firmly attached to the tank.

Pyrex pipe is somewhat more expensive than iron pipe and is priced slightly above full weight copper or brass. However, it is considerably lower than alloy steels. The average costs per running foot in a typical installation are listed below.

Pipe Size, Inches I.D.	Cost per Foot
1	$1.00
1½	1.75
2	2.10
3	3.25
4	6.00

Installation costs vary considerably depending on the system required. They may be anywhere from 25 to 80% of the glass cost for 2 in. pipe.

When sizes greater than 4 in. I.D. are required to convey corrosive fumes and gases at low pressure, socket or bell and spigot type pipe is available in various diameters up to 18 in. O.D. The details of this type of pipe are listed in Table I.

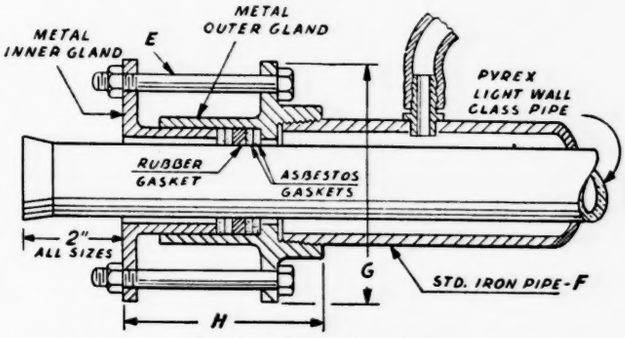
Fractionating columns, gas absorbers and other types of equipment can also be constructed from socket pipe. A perforated glass plate is inserted between each section and the tower is filled with raschig rings, coke, glass fibres or any type of packing material. Special top and bottom closures can be supplied to suit the type of installation.

Glass Heat Exchangers

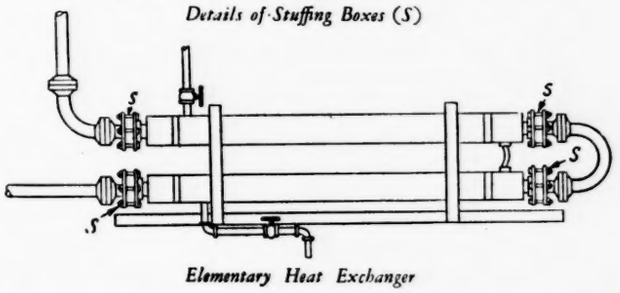
For heating or cooling corrosive fluids, foods or medicinal products, glass heat exchangers of the double pipe type are available. The construction details are illustrated in Fig. 2 and Table III. Lengths of light wall glass piping are enclosed in standard metal pipe by means of stuffing boxes and connected in series by means of U-bends. Steam or heating or cooling water may be circulated in the exterior jackets thus formed, heating or cooling the liquid or gas in the glass piping. The corrosion resistance of glass insures a heat exchanger of long life during which heat conductivity is virtually unchanged by scaling or surface pitting.

Thermal conductivity of glass is considerably lower than that of the common metals. However, in most exchangers, the films of stagnant fluid adjacent to the tube walls constitute the major source of resistance to heat transfer.

Also, the glass smoothness of the glass pipe walls resists fouling or accumulation of heat insulating scale. Hence, the overall heat conductivity of a glass unit usually compares very favorably with one constructed entirely of metal. Representative values of the overall heat transfer coefficients of glass exchangers are illustrated in Table II.



Details of Stuffing Boxes (S)



Elementary Heat Exchanger

TABLE III.—HEAT EXCHANGER DETAILS

Pipe Size, Inches	E Inches	F Inches	G Inches	H Inches	J*
1	$\frac{5}{16}$ x 3	2	$4\frac{1}{2}$	$3\frac{1}{2}$	9'2"
$1\frac{1}{2}$	$\frac{5}{16}$ x 3	$2\frac{1}{2}$	5	$3\frac{3}{4}$	9'1½"
2	$\frac{5}{16}$ x 3	3	$5\frac{5}{8}$	$3\frac{7}{8}$	9'1½"
3	$\frac{5}{16}$ x 3	$4\frac{1}{2}$	7	$4\frac{1}{8}$	9'1"
4	$\frac{3}{8}$ x $3\frac{1}{2}$	6	$9\frac{3}{4}$	$4\frac{7}{8}$	9'0"

*J = length of metal pipe for Jacket for 10 ft length of glass pipe.

TABLE II.—TYPICAL OVERALL HEAT TRANSFER COEFFICIENTS FOR VARIOUS SIZE "PYREX" JACKETED TUBES

Process	Fluid Inside Glass Tube	Mass Velocity G Inside Lb/Hr/Sq Ft	Average Inside Temp. F	Fluid Outside Tube (In Jacket)	Mass Velocity G Outside Lb/Hr/Sq Ft	Average Outside Temp F	Approx. Overall "U" Btu/Hr/Sq Ft/F				
							1 In.	1½ In.	2 In.	3 In.	4 In.
Liquid Cooling	Saturated Aqueous Chlorine Soln.	$5x10^5$	150	Water	$5x10^5$	100	94	93	92	68	52
Liquid Heating	5% HCl Solution	$5x10^5$	150	Steam	....	250	114	113	112	89	64
Condensing Pure Vapor	Benzene	....	176	Water	$5x10^5$	100	86	85	84	64	52
Gas Cooling	Dry Diatomic Gas	$8x10^3$	200	Water	$5x10^5$	100	4.4	4.2	3.9	3.6	3.3

Sol-Air Temperature—A New Concept

C. O. MACKEY
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RECENTLY, a new term was introduced that is important to engineers interested in weather data, and in the combined effect of solar radiation and outdoor air temperature upon heating and cooling loads. In the earlier paper, this term was called "equivalent temperature" of the outdoor air. Since the term "equivalent temperature" has been used elsewhere as an index of indoor comfort conditions, the alternative term of "sol-air temperature" was substituted.

Sol-air temperature means the temperature of the outdoor air, which in contact with a completely shaded building surface, would give the same rate of heat entry into the outdoor surface of that material as exists with the actual dry-bulb temperature of the outdoor air, the actual intensity of solar and sky radiation incident upon that surface, and the actual wind velocity. The advantages of such an index which combines the effect upon heat transfer of these three variables is probably obvious, and the engineering uses will be illustrated later by examples.

There are two general classifications of building materials of interest in heat transfer calculations. One type of building material is that which does not directly transmit incident solar radiation; examples are brick, concrete, stone, and wood. A fraction (the absorptivity) of the total radiant energy incident upon such materials is absorbed, and the remaining fraction (the reflectivity) is reflected. Another type of building material, like glass, not only absorbs a fraction of the total incident radiation and reflects a fraction, but also directly transmits a fraction (the transmissivity) of the total incident radiation.

For a material which does not directly transmit any of the incident radiation (transmissivity of zero), the rate of heat entry into the surface of that material, when exposed to outdoor air and incident solar and sky radiation, is:

$$\left(\frac{q}{A}\right)_1 = bI + h_1 (t_a - t_1)$$

where $\left(\frac{q}{A}\right)_1$ = rate of heat entry into surface, Btu per hr per sq ft;

b = absorptivity of the surface for incident solar and sky radiation (dimensionless);

I = intensity of incident solar and sky radiation, Btu per hr per sq ft;

t_a = temperature of outdoor air in the shade, F;

t_1 = temperature of outside surface of material, F;

h_1 = combined surface coefficient of heat transfer, Btu per hr per sq ft per degree.

Now,

$$bI + h_1 (t_a - t_1) = h_1 \left(t_a + \frac{bI}{h_1} - t_1\right)$$

Let the sol-air temperature, $t_e = t_a + \frac{bI}{h_1}$.

Then,

$$\left(\frac{q}{A}\right)_1 = h_1 (t_e - t_1)$$

In other words, the rate of heat entry into the material is precisely as if the temperature of the outdoor air were equal to the sol-air temperature, t_e, with no incident solar and sky radiation.

As a numerical example of this case, assume steady flow of heat (no storage), a building wall with a thickness of 6 in., a thermal conductivity of 12 Btu per in. per hr per sq ft per degree, and a solar absorptivity of 0.4. Let the temperature of the outdoor air be 95F and the incident solar radiation be 240 Btu per hr per sq ft. For a temperature of the indoor air of 80F, the rate of steady flow of heat through this material would be found in the conventional manner as follows (when the combined outdoor air film coefficient of heat transfer is 4 Btu per hr per sq ft per degree, and combined indoor air film coefficient of heat transfer is 1.65 Btu per hr per sq ft per degree):

$$\frac{q}{A} = 0.4\ (240) + 4\ (95 - t_1) =$$

$$\frac{12}{6} (t_1 - t_o) = 1.65\ (t_o - 80),$$

from which it may be shown that

$$t_o = 97.4F;\ t_1 = 111.6F;\ \text{and}\ \frac{q}{A} = 28.8\ \text{Btu per hr per sq ft}$$

By the method of sol-air temperature, the sol-air temperature is:

$$t_e = 95 + \frac{0.4\ (240)}{4} = 119F$$

The overall coefficient of heat transfer is:

$$U = \frac{1}{0.25 + 0.5 + 0.606} = 0.738\ \text{Btu per hr per sq ft per degree}$$

and the corresponding rate of heat transfer is:

$$\frac{q}{A} = 0.738\ (119 - 80) = 28.8\ \textit{Btu per hr per sq ft}$$

The rate of heat flow and the temperature distribution through the material are precisely as if the temperature of the outdoor air were 119F (the sol-air temperature) with no solar or sky radiation incident upon the surface.

Although the example chosen is, for simplicity, one of steady flow of heat, the sol-air temperature correctly collects into one index the combined effects of air temperature and solar radiation for the unsteady flow of heat. The sol-air temperature, in combination with the outdoor air film coefficient of heat transfer, determines the rate of entry of heat into the outside surface of the material independent of whether there is or is not storage of heat within the material as the conduction proceeds.

For materials which directly transmit some of the incident solar radiation, such as glass, the sol-air temperature must be found in a slightly different manner. If the transmissivity of the material (the ratio of the radiation directly transmitted to the total incident radiation) be designated by m, the total rate of steady flow of heat through a material due to solar radiation directly transmitted and heat conducted is:

$$\frac{q}{A} = mI + U\left[(t_a - t_i) + \frac{bI}{h_i}\right]$$

Note that

$$mI + U\left[(t_a - t_i) + \frac{bI}{h_i}\right] = U\left[\left(t_a + \frac{bI}{h_i} + \frac{mI}{U}\right) - t_i\right]$$

For this case, let the sol-air temperature be:

$$t_e = t_a + I\left(\frac{b}{h_i} + \frac{m}{U}\right)$$

Then,

$$\frac{q}{A} = U\ (t_e - t_i)$$

In this case, there is a contribution to the sol-air temperature, not only from the air temperature t_a and the modulus $\frac{bI}{h_i}$ (dimensions of temperature), but also from $\frac{mI}{U}$ (dimensions of temperature).

When the transmissivity, m, is zero, the sol-air temperature for this case is the same as in the preceding case.

As a numerical example of this case, assume steady flow of heat through a single thickness of window glass with $t_a = 95$F, $I = 300$ Btu pr hr per sq ft; $h_i = 4$ Btu per hr per sq ft per degree; $h_o = 1.65$ Btu per hr per sq ft per degree; $U = 1.1$ Btu per hr, per sq ft, per degree; $t_i = 80$F. Assume, furthermore, that the solar radiation is perpendicular to the glass. For normal incidence, the solar absorptivity of this glass is about 0.04 and the transmissivity about 0.88.

The sol-air temperature is:

$$t_e = 95 + 300\left(\frac{0.04}{4} + \frac{0.88}{1.1}\right) = 338F$$

The rate of steady heat transfer through the glass due to direct transmission of solar radiation and conduction of heat absorbed is:

$$\frac{q}{A} = 1.1\ (338 - 80) = 284\ \textit{Btu per hr per sq ft}$$

This rate of heat transfer is precisely as if the temperature of the outdoor air were 338F with no solar radiation incident upon the glass. The distribution of temperature throughout the glass is different, however, because the energy directly transmitted does not warm the glass; the temperature at any point in the glass is the same as if the temperature of the outdoor air were

$$t_e = 95 + \frac{0.04\ (300)}{4} = 98F,$$

which is the sol-air temperature with $m = 0$.

The transmissivity of window glass varies greatly with the angle of incidence of the sun's rays[1]. To apply the concept of sol-air temperature to finding the contribution to the cooling load due to heat transfer through glass requires that the absorptivity and transmissivity be known as a function of this angle.

Engineering Application

One of the engineering uses of sol-air temperature is in the interpretation of summer weather data. For north latitudes in the region of 40 degrees, the maximum air temperatures commonly occur during the month of July while the solar and sky radiation incident upon a horizontal surface reaches its maximum intensity during June. Sol-air temperature gives a a rational means of determining the true effect upon the cooling load of the combinations of air temperature and solar radiation that actually occur simultaneously.

For example, on June 17, 1933, in Lincoln, Neb., the temperature of the outdoor air in the shade at 2 pm was 92F, while the total solar and sky radiation incident upon a horizontal surface was 323 Btu per hr per sq ft; at the same time, the wind velocity was 14 mph. In the same city on July 1, 1933, the temperature of the outdoor air in the shade at 2 pm was 108F and the total solar and sky radiation incident upon a horizontal surface was 278 Btu per hr per sq ft with a wind velocity of 14 mph.

The sol-air temperature concept answers the fol-

lowing question: Which of these conditions creates a more severe cooling load on a horizontal roof with a solar absorptivity of 0.9? If the outdoor combined film coefficient of heat transfer (h_1) be taken as 6 for the wind velocity of 14 mph, the sol-air temperatures follow:

$$\text{June 17, 1933:} \quad t_e = 92 + \frac{0.9\,(323)}{6} = 140F$$

$$\text{July 1, 1933:} \quad t_e = 108 + \frac{0.9\,(278)}{6} = 150F$$

Since the sol-air temperature for this roof was 10F higher on July 1, than on June 17, the larger effect upon the cooling load was on July 1.

In applying this sol-air temperature concept to the interpretation of summer weather data, there are some gaps in weather information now available. The U. S. Weather Bureau maintains several stations where the hourly intensity of total solar and sky radiation on a horizontal surface is measured with a pyrheliometer; the hourly dry-bulb temperature of the air in the shade and the hourly wind movement are also measured. Very few observations have been made, however, on the intensity of solar and sky radiation incident upon vertical surfaces of various orientations at different times of the day. Since there are different sol-air temperatures at any given time for surfaces with the same solar absorptivity but different positions—horizontal or vertical—or different orientations, if vertical—the engineer would like to know more than the solar and sky radiation incident upon horizontal surfaces. The best he can do at present is to estimate the intensity of radiation incident upon vertical surfaces of various orientations from the observed intensities on the horizontal. If it were not for the fact that part of the total observed radiation incident upon the horizontal surface is diffuse or sky radiation, it would be a relatively simple trigonometric problem to calculate the intensity on a vertical surface from the observations for the horizontal.

Radiation Ratio

As solar radiation passes through the earth's atmosphere, part is turned aside from the direct beam and scattered in practically all directions with no appreciable change in wave length. A considerable portion of the total radiation incident upon the horizontal is in the form of this diffuse radiation from the sky. On cloudy days, all radiation is diffuse, while on clear days the ratio of direct to diffuse radiation varies with the solar altitude and with the amount of dust, water vapor, and other materials in the atmosphere. This ratio is small for low solar altitudes, cloudy days, and large amounts of smoke and dust in the atmosphere. On clear days in cities, near the times of sunrise and sunset, the diffuse radiation may amount to more than one-half the total received on the horizontal. From a large number of measurements of diffuse radiation, Dr. I. F. Hand gives the following table[2] for the ratio of direct solar radiation on a horizontal surface to diffuse sky radiation on that surface during cloudless days in Washington, D. C.:

Solar altitude	60°	30°	11.3°
Ratio of direct to diffuse radiation, summer	5.2	3.1	1.5
Ratio of direct to diffuse radiation, winter	8.1	5.0	1.7

These results are believed to be typical for eastern states.

If the solar and sky radiation received on a horizontal surface and the solar altitude are known for each hour of the day, a graph of the above tabular values will permit the estimated breakdown of solar and sky radiation into the respective components on the horizontal. By trigonometric methods, the direct solar radiation incident on any vertical surface may then be found from the direct solar radiation incident on the horizontal[3]. The point of greatest uncertainty is the estimate of the corresponding diffuse sky radiation on the vertical surface.

Only more complete data would permit a precise answer to this problem. Without such data, one simple basis for an engineering estimate is to assume that, at any time, the diffuse radiation incident upon a vertical surface is one-half of that incident upon the horizontal at the same time. Any such estimate of the total solar and sky radiation received on a vertical surface will be in error by an amount equal to the difference between the actual incident diffuse radiation and one-half of the diffuse radiation incident on the horizontal. Since this difference will, at most hours of the day, be a small percentage of the total incident radiation, the resulting error in the sol-air temperature for vertical surfaces will not be great.

The solar absorptivity of a surface, unlike the absorptivity for radiation emitted by sources at moderate temperatures, depends on the color of the surface. Solar absorptivities for some common surfaces follow[4]:

Solar Absorptivities

Very light colored surfaces (white stone; light colored cement; white or cream paint, etc.)	0.4
Medium dark colored surfaces (shingles; unpainted wood; brown stone; brick; red tile; dark-colored cement; stucco; red, green, or gray paints, etc.)	0.7
Very dark colored surfaces (slate roofing; tar roofing; very dark paints)	0.9

The proper value to use for the combined outdoor air film coefficient of heat transfer (h_1) in calculating sol-air temperature depends upon the radiant heat exchange at the outdoor surface as well as the true convective transfer of heat between outdoor air and building surface. When two solid surfaces of common building materials at ordinary temperatures ex-

change heat by radiation, the equivalent film coefficient is about 1 Btu per hr per sq ft per degree for moderate temperature differences. The true convective film coefficient depends upon surface roughness and air movement; for large vertical surfaces with natural convection, only, this coefficient is about 0.5 Btu per hr per sq ft per degree for a temperature difference of 12F. If the temperature of surrounding solid surfaces is the same as that of the air, the combined film coefficient of heat transfer at the outside surface might be expected to take the following approximate form[5]:

$$h_1 = 1.5 + CV^{0.8},$$

where

C = a constant that depends primarily upon surface roughness;
V = wind velocity (zero for natural convection).

The heating and ventilating engineer commonly uses a winter value of 6 Btu per hr per sq ft per degree for h_1, which is based upon a wind velocity of about 15 mph. A study of summer weather data in Lincoln, Neb., recently completed by the author indicates what wind velocities may be expected in one locality, at least, during July. Based upon 155 readings at each hour during July for a 5-year period (1932-1936), the average hourly wind movement for the hour ending at 9 am was 9.7 miles, at 12 noon, 10.5 miles, and at 3 pm, 11.1 miles. The maximum hourly wind movement observed in the same period was 19 miles for the hour ending at 9 am, 22 miles at 12 noon, and 20 miles at 3 pm. The minimum hourly wind movement in the same period was 3 miles at 9 am and at 12 noon, and 4 miles at 3 pm. There was no correlation between sol-air temperature and wind movement. Based upon a summer wind velocity of 10 mph, the expected value of the combined coefficient would be about 4.0 Btu per hr per sq ft per degree.

Horizontal building surfaces, such as roofs, do not commonly exchange heat by radiation with other solid surfaces at air temperature. Instead, these surfaces receive solar and diffuse sky radiation in the short wave lengths, receive radiation in longer wave lengths that is absorbed by the water vapor in the earth's atmosphere, and emit radiation to the sky in the longer wave lengths after absorption of incident radiation at the surface. The net effect is commonly as if the total solar and sky radiation incident upon these surfaces were lower than that actually received; during the night hours, the sol-air temperature is actually lower than the air temperature.

If the radiant heat exchange could be evaluated precisely, the true convective film coefficient of heat transfer of 3.0 for a wind velocity of 10 mph should be used. The complications in finding the exact rate of heat transfer at the building surface are so great that the simplest procedure is to use only the total solar and sky radiation incident upon the surface as measured by the Weather Bureau combined with a constant, combined value of the outdoor air film coefficient of heat transfer. The use of a constant value of 4 Btu per hr per sq ft per degree for this combined coefficient will probably be as accurate in estimating summer cooling loads as is the present common use of a constant value of 6 in estimating winter heating loads.

Another application of sol-air temperature is in the study of winter heating economy. There has been much loose talk about the extensive use of glass to utilize solar heat in post-war housing—and very few facts. It is a tedious study to gather these facts, but hourly winter sol-air temperatures for glass of different orientations in different cities would help in solving this problem. The general problem might be stated as follows: Will the use of a single thickness of window glass of a given orientation in a given community result in a net gain or a net loss of heat from the structure during an entire, typical heating season when compared with a wall of the typical thermal resistance in its place?

It is probable that single glass facing north, for example, would be a thermal liability and the same glass facing south a thermal asset. But the solar radiation incident upon a surface of a particular orientation during an entire heating season in Community A is not the same as that in Community B; glass may be a thermal asset in A and a liability in B. Again, what is the effect of substituting double glass? This would reduce both the conduction loss of heat from inside to outside and the solar heat directly transmitted in the opposite direction—single glass of a particular orientation might be a thermal asset and double glass a thermal liability in one location, or vice versa.

In any case, heating engineers might like to have a few more facts. The facts are these—the daily loss of heat per square foot of building surface of a particular orientation is:

$$\frac{q}{A} = 24U\,(t_{1m} - t_{em}),$$

where $\frac{q}{A}$ = daily loss of heat per square foot of surface, Btu;
U = overall coefficient of heat transfer, Btu per hr per sq ft per degree;
t_{1m} = average temperature of indoor air for entire day, F;
t_{em} = average daily sol-air temperature for the particular surface and locality.

This result is true for steady flow of heat (no storage of heat) and for unsteady flow of heat which is periodic in 24 hours.

Any complete investigation of the thermal advantage of glass must compare the seasonal loss of heat through glass with the seasonal loss of heat through the wall which the glass replaces, and the sol-air temperatures may be used conveniently in making this comparison. It must be remembered that solar radiation incident upon all building surfaces is partially absorbed in the winter as well as in the sum-

mer, and such absorption affects the winter heating load as well as the summer cooling load.

Let the number of hours in the heating season be designated by N, the average sol-air temperature for a window of a particular orientation for the entire heating season be t_{eg} and the winter overall coefficient of heat transfer for this glass be U_g Btu per hr per sq ft per degree. Let the winter overall coefficient of heat transfer for the wall of the same orientation be U_w Btu per hr per sq ft per degree and the average sol-air temperature of this wall for the entire heating season be t_{ew}. Assume the average temperature of the indoor air for the entire heating season is t_i. For the same seasonal loss of heat through window and wall,

$$NU_g\,(t_i - t_{eg}) = NU_w\,(t_i - t_{ew})$$

From this equation it may be shown that for equal seasonal heat loss,

$$t_{eg} - t_{ew} = \frac{(U_g - U_w)\,(t_i - t_{ew})}{U_g}$$

In other words, the average seasonal sol-air temperature for the glass must exceed the average seasonal sol-air temperature for the wall which it replaces by the amount shown by the right side of this equation before the glass becomes a thermal asset. This comparison does not consider relative costs of glass and wall, nor any other merits of glass versus wall. Neither does it include the loss of heat due to infiltration of outdoor air around the movable section of the window, for the reason that this arrangement provides ventilation and other functions not duplicated in the wall. It does tell whether the seasonal transmission of heat through glass or wall is the greater.

A numerical example will be given: Assume single glass is being considered with $U_g = 1.13$ Btu per hr per sq ft per degree, while the wall is frame construction with $U = 0.25$ Btu per hr per sq ft per degree. Assume a study of weather data shows that the average sol-air temperature of this wall is 45F for the entire heating season and the assumed orientation. Assume the average temperature of the indoor air for the entire season is 65F. Then, for a smaller seasonal loss of heat through the glass than through the wall, the average sol-air temperature of the single glass for the entire heating season and selected orientation must exceed

$$t_{eg} = 45 + \frac{(1.13 - 0.25)\,(65 - 45)}{1.13}$$
$$= 45 + 15.6 = 60.6F$$

Notice, also, that the wall may be more effectively insulated without any change in its seasonal sol-air temperature; assume, that by such insulation, U_w is reduced to 0.1 Btu per hr per sq ft per degree. Then, the seasonal sol-air temperature of the single glass, in this example, must exceed

$$t_{eg} = 45 + \frac{(1.13 - 0.10)\,(65 - 45)}{1.13}$$
$$= 45 + 18.2 = 63.2F$$

The use of a double-glass window will reduce U_g but it will also change the actual average seasonal sol-air temperature of the glass.

A third important engineering application of the sol-air temperature concept is in experimental work. Since the absorptivity of a surface for solar radiation is different from the absorptivity of the same surface for radiation emitted by sources at temperatures lower than that of the sun, it has been thought necessary, in the past, to use solar radiation in all experiments relating to the transmission of solar heat.

Assume that the problem is to investigate the heat transmitted to indoor air from a wall panel exposed on its other face to outdoor air temperature and solar radiation. In the past, such panels have been set up in different places and with different orientations in each locality—the next step was to wait for the sun to shine in the hope that at some time during the course of the experiment the combination of outdoor air temperature and solar radiation would approximate the design conditions. The sol-air concept separates the thermal performance of the test panel from the weather conditions. If the absorptivity for solar radiation of the outdoor surface of the test panel is known, a study of summer weather data will yield the hourly sol-air temperature vs time graph which will serve as the design curve for this material in any selected orientation.

Now the test panel may be set up entirely within a laboratory—it need not be exposed to solar radiation—all that is necessary in the investigation of heat transmission is that the temperature of the air sweeping the outdoor surface of the panel be regulated in time to correspond to the sol-air temperature vs time graph and that the air movement at this surface be equal to the average air movement assumed in obtaining the sol-air temperatures. The thermal performance of the panel will then be the same as if it were exposed to solar radiation and outdoor air temperature. Instead of having several panels with different orientations, the effect of orientation may be reproduced by changing the air temperature vs time to conform to the sol-air vs time temperature of any particular orientation.

There are quite a few laboratories in this country where model or full-scale rooms are set up within test rooms in which the temperature and air movement in the shell spaces may be controlled. In such test rooms, the combined effects of solar radiation, air temperature, and air movement upon heat transmission may be investigated although no solar radiation is ever incident upon the outside surface of the inner room.

In order to place the sol-air temperatures for vertical surfaces upon as firm a basis as are those temperatures for horizontal surfaces, more observations of the intensity of solar and sky radiation incident upon vertical surfaces of different orientations are needed. Perhaps the U. S. Weather Bureau might consider measuring such radiation intensities. They have already made a large number of determinations

(Concluded on page 121)

An introduction to

Convection Drying and Drying Calculations

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DRYING is one of the oldest observed phenomena, but in spite of its age is still in its infancy as far as human knowledge and understanding of it are concerned. It can be defined as a process tending toward the concentration of solids. However, drying processes as dealt with in this article are the removal of liquid, usually water, from a material by evaporation. This field, as defined, is vast. It consists of three types of objectives: removal of moisture added during processing, removal of water from raw or prepared material for the sake of reduction in bulk or preservation, or removel of water for the control of the final residual moisture in the product.

Drying has been and is an art, and not a science. The oldest form is "sun drying" of fish, macaroni, grain, coffee, and other foods. Drying of ceramic wares was carried out, however, in the shade. Thus the necessity of gradual or retarded moisture liberation was recognized thousands of years ago.

Various degrees of progress in the drying field were made on the basis of experience and were, therefore, restricted to specific materials. In the course of many years certain drying systems became known and associated with the products and industries they served. Convenience of purchasing further assisted in the creation of traditional dryer types. Further progress was thus impeded; manufacturers of drying equipment stuck to their well-beaten and profitable paths and deviated very little from specialized industries they served. Today the number of "standard" dryers on the market is astonishing. This condition is representative of an art in which underlying principles are only vaguely understood.

However, in the past few years this situation began to change. The knowledge gained, first during the pre-war advance of the art of air conditioning and then in food dehydration, gave an impetus to drying. Numerous new air treating and air handling devices as well as new material heating methods were developed and successfully applied to drying operations by men with no previous experience in drying. Because of the lack of experience or the speed of expansion, the newcomers had their original setbacks, but the wheels of progress started to turn. It became painfully evident that a thorough understanding of somewhat involved drying principles is necessary effectively to attain desired results.

Obviously, there are basic fundamentals, the understanding of which will enable one to solve drying problems, not in terms of complex defferential equations but in terms of production. The scope of this article then, is to outline a rational approach to drying problems, to point out the variables involved and their proper evaluation, to present the theory of control of drying operation, and to formulate the procedure of converting experimental and theoretical data into a completed drying installation.

In order correctly to evaluate the physical and chemical changes in the material during the drying operation, a clear understanding of general properties and drying terminology is imperative. Drying literature is full of vague definitions, and although precise definition of terms is very difficult, yet it could save time and confusion.

TERMINOLOGY

Materials consist of solids and moisture. *Bone dry* state of the material implies complete absence of moisture.

Moisture content is usually expressed in terms of percent on *wet* or *dry* basis, as shown below.

Usually the wet basis is used. It could easily be shown that a seemingly small discrepancy in the initial moisture content expressed on a wet basis will cause a considerable increase in the amount of water to be removed from the product. The wet basis has the advantage that the summation of the percentage of solids and moisture must always be equal to 100. To avoid errors, use the following formulas:

$$W_1 = S_1 + M_1$$
$$W_2 = S_2 + M_2$$

where W_1 = initial weight of material to be dried
M_1 = weight of moisture in entering material
W_2 = final weight of material leaving dryer
M_2 = weight of moisture in leaving material
S_1 = initial weight of solids
S_2 = final weight of solids

When the foregoing formulas are used each totals 100 if *each term is in per-cent. If each term is in pounds*, S_1 and S_2 are identical.

$$U = W_1 - W_2 = M_1 - M_2$$

when the units are in pounds per hour, and U is the *unit dryer duty in pounds per hour.*

The difference between the initial and final weights of either the material or moisture content must be equal and represent the *total drying duty* or *load.* In case of continuous drying, the *unit drying duty* signifies the rate of moisture removal per unit of time.

$$\text{Per-cent moisture content, wet basis} = \frac{\text{Weight of moisture in the sample}}{\text{Weight of the sample}}$$

$$\text{Per-cent moisture content, dry basis} = \frac{\text{Weight of moisture in the sample}}{\text{Weight of solids in the sample}}$$

Therefore:

$$\text{Per-cent moisture content, wet basis} = \frac{\text{Per-cent moisture content, dry basis}}{100 + \text{Per-cent moisture content, dry basis}}$$

or

$$\text{Per-cent moisture content, dry basis} = \frac{\text{Per-cent moisture content, wet basis}}{100 - \text{Per-cent moisture content, wet basis}}$$

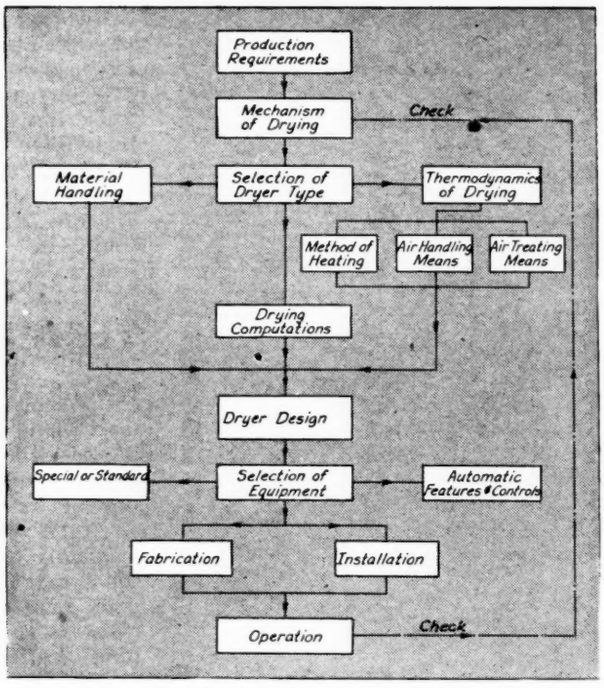


Fig. 1. Organization chart of drying problem.

The following example will illustrate the foregoing definitions:

Example. A production of 1000 lb of material per hour is required. The material has an initial moisture content of 40%, wet basis, and a final moisture content of 12%, wet basis, is desired. What is the initial weight of material entering the dryer and what is the unit drying duty?

Solution. The required production of 1000 lb per hr is the final weight of material. Since the final moisture content is 12%, then

$$W_2 = S_2 + M_2 = 100$$
$$S + 12 = 100$$
$$S = 88\% \text{ in terms of final weight}$$

Since $W_2 = 1000$ lb, $M_2 = .12 \times 1000 = 120$ lb, $S_2 = 0.88 \times 1000$ lb, $= 880$ lb.

$$\text{Since } W_1 = S_1 + M_1 = 100$$
$$S_1 + 40 = 100$$
$$S_1 = 60\% \text{ in terms of initial weight}$$

But S is constant in actual weight (880 lb) so that the initial weight of material $W_1 = \frac{880}{.60} = 1467$ lb. M_1 is thus $1467 - 880 = 587$ lb.

$$U = W_1 - W_2 = 1467 - 1000 = 467 \text{ lb per hr.}$$
$$U = M_1 - M_2 = 587 - 120 = 467 \text{ lb per hr.}$$

Numerous dry materials when exposed to air will absorb a fixed amount of moisture from the air, depending on the temperature and humidity. Conversely, the same materials when moist, when exposed to air at identical temperature and humidity, will lose or *desorp* a certain amount of their moisture to the air. Such materials are called *hygroscopic*, and it is said that they reach equilibrium with the surrounding air when no further changes take place. The amount of moisture they contain will depend on the humidity and temperature of the air. At a constant temperature, their *equilibrium moisture content*, always expressed in terms of percent moisture, dry basis, will be greater as the relative humidity increases. At a fixed relative humidity, the equilibrium moisture content will be less the higher the temperature.

The moisture retained by the material in equilibrium with the air is called *bound, combined, hygroscopic,* and sometimes even *absorbed* moisture. The amount of moisture a wet material gives to the air before reaching the equilibrium is called *unbound, free* and sometimes *capillary* moisture.

This nomenclature is greatly misleading and sometimes even contradictory. Graphic presentation (Fig. 2) clarifies this situation and illustrates the relation of these terms to the drying operation. Plotting of a series of equilibrium moisture content points will form a *moisture equilibrium curve* specific to a given material exposed to air at a constant dry bulb temperature and varying relative humidity.[1]

The area above the intersection of this curve with the 100% relative humidity ordinate represents unbound moisture, whereas the area below this horizontal line represents bound, combined or hygroscopic moisture. The dividing horizontal line is called the *fiber saturation moisture content*, which is practically the same as *critical moisture content.*

For any point on this curve, corresponding to a given percent of relative humidity, the moisture content as measured by the ordinate below the curve is called either regain or equilibrium moisture content. The moisture contained in the material in excess of regain is called *free*

[1]Moisture equilibrium curves are also sometimes called *isotherms*, apparently to indicate that the data hold true only at a specified dry bulb temperature. Abroad, the term *isopiestics* has also been used to stress the idea that, for every point on the curve, the vapor pressures of vapor in the air and of moisture in the material are equal. Hence, isopiestic, meaning equal pressures.

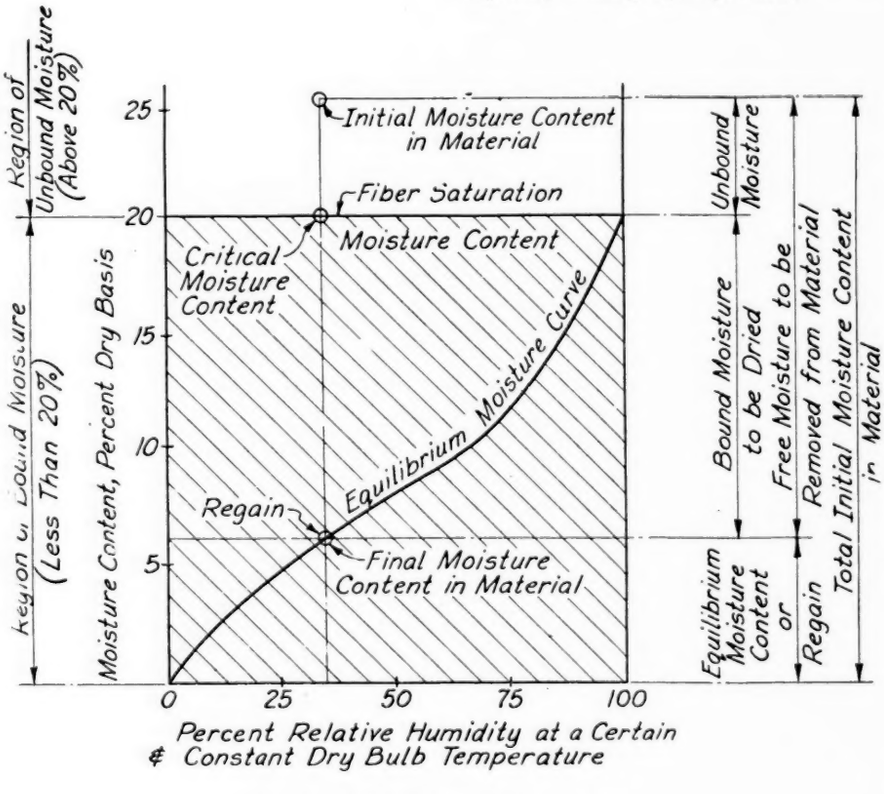


Fig. 2. Moisture equilibrium curve.

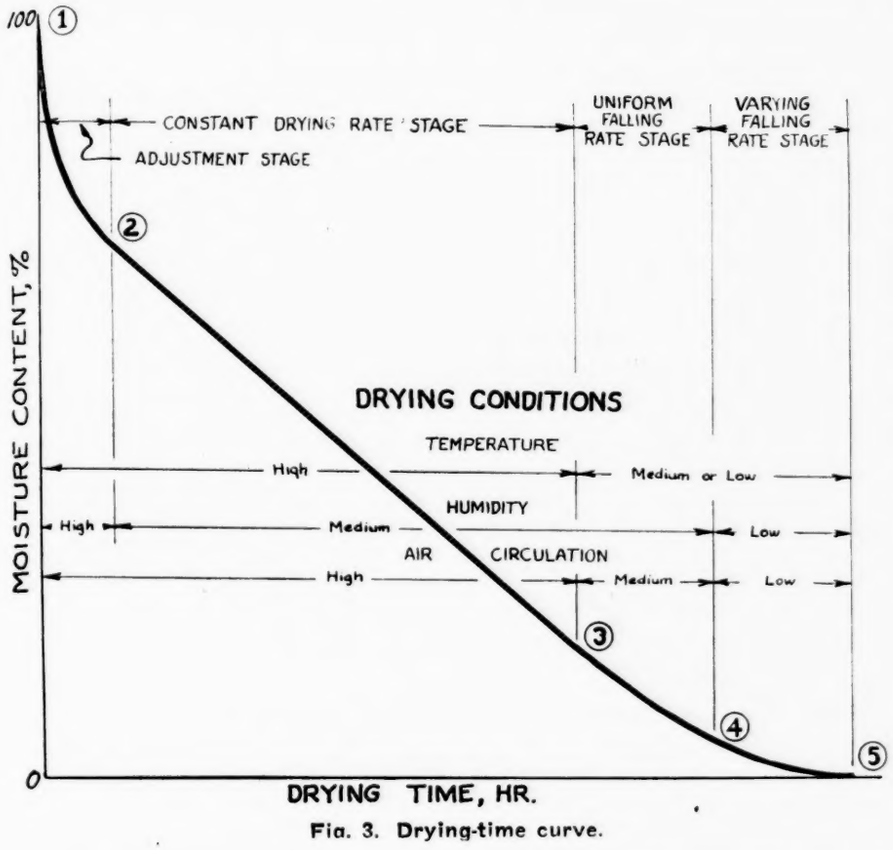


Fig. 3. Drying-time curve.

moisture, which may consist of unbound and some bound moisture depending upon the initial moisture content of the material.

Before leaving the subject of terminology, it should be emphasized that *efficiency* is a much misused term in drying. Efficiency is an indicator of achieved or contemplated results in relation to a possible perfection. Unless both the results and the goal are clearly defined the efficiency is meaningless. For example, heat consumptions of two dryers per unit of time cannot be compared unless the drying times are also equal. There are other variables such as conditions of make-up air, physical condition of equipment, energy required for preparation of material prior to drying, power consumed by fans and other machinery, and the operating cost. Well hidden, but nevertheless omnipresent, are the obsolescence cost with attached cost of maintenance and delays in production. All of these are inter-related with efficiency.

The prime purpose of a dryer is to remove moisture from the material, and not to save heat or power. Yet, in numerous instances, the desire to economize fuel or power has retarded the drying process; cost of fuel was reduced, but the cost per unit of production was substantially increased.

One of the most common questions is "how many pounds of steam are required to remove one pound of water from the product?" The answer lies not in the literal answer but in the cost of the product and, therefore, in the cost of one pound of residual water in the dried product. Drying of low priced and competitive products, such as paper and fertilizers, does require utmost heat economy which is achieved through the utilization of efficient heat supplying devices, but at the same time the second phase of drying—namely, the removal of liberated moisture—is usually neglected. Fortunately, in these cases, the final moisture content is required to be neither low nor exact. It will be explained later that the maximum energy consumption takes place during the final drying stage, and that the thermodynamic efficiency then loses most of its significance.

PLANNING THE SOLUTION

"To know what to ask is to know half," a Greek philosopher said two thousand years ago. A clear and complete statement of a drying problem may require considerable time and effort, but a functional subdivision of the available data and lacking information will make it possible for one to avoid repetition of work and save time.

The drying problem can be divided into four distinct phases, as follows:

1. Production requirements;
2. Study of the material proper;
3. Determination of best drying conditions to suit the specific material; and
4. Selection or design of a drying installation.

For the sake of clarity, the organization chart of a drying problem (Fig. 1) points out graphically the interrelation of the above phases and shows the sequence of solution from a nebulous state to the actual production of dried material.

It must be understood that the costs and efficiencies involved, while not shown on the chart, nevertheless influence to a considerable extent the whole matter. The size of the job, the market conditions, and the selling price of the product must justify the expenditures of time and money on planning and research. Therefore, one cannot overemphasize the value of proper interpretation of new or previously accumulated information for the purpose of future reference.

PRODUCTION REQUIREMENTS

Analysis of production loads in drying is no different from that in any other manufacturing process. The drying installation has to meet one or more of the following requirements:

1. Production in large quantities of identical or very similar materials, otherwise known as *continuous mass production;*
2. Production in moderate quantities of various materials, or *intermittent* production;
3. Production in small lots of widely different materials, or batch operation, as in a jobbing shop.

It is almost axiomatic that large production of identical material should be carried out on a *continuous* basis. Material handling and time are of prime consideration. Material handling means are designed to suit loading and unloading operations and, if possible, are made to accommodate simultaneously a variety of materials. Material is moved through the dryer from station to station by either power-driven mechanisms or manually. The time intervals are also either automatically regulated by a clock or manually. Typical examples of these dryers are found in the ceramic industry.

Prolonged drying time is often given as an objection to use of a continuous process. While it is quite true that the longer the material has to remain in the dryer, the larger the dryer will be and the higher may be the initial cost. But, on the basis of equal output per unit of time, the batch drying operation will take longer due to the time required to load and unload the

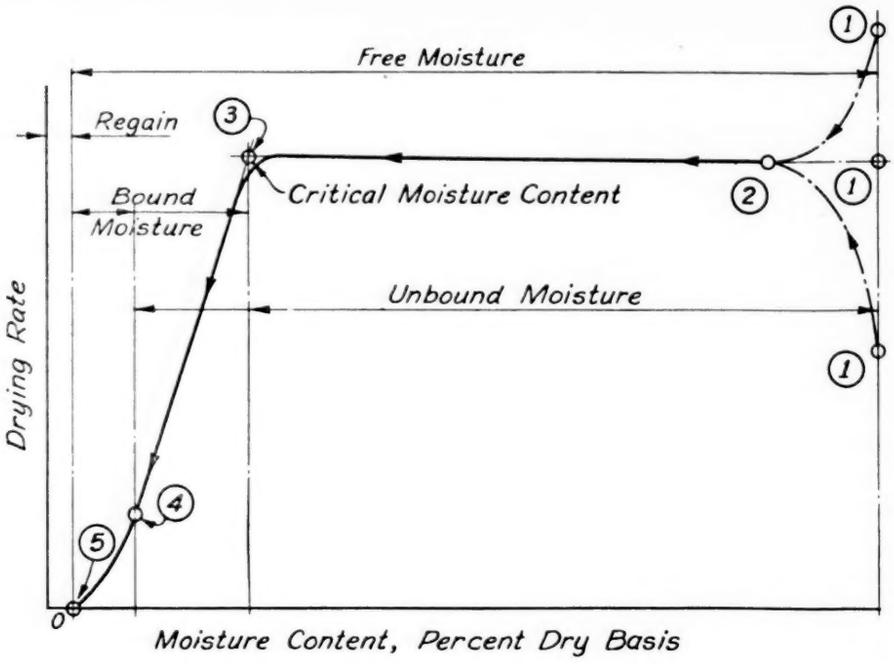


Fig. 4. Drying-rate curve.

dryers. This condition will be further aggravated should the material be required to travel long distances between the loading station, dryer, and the unloading station. The labor, and therefore, the operating cost will also be substantially higher.

Batch drying must also be scheduled on a day to day basis, or even fractions thereof, if the labor shifts or daily work tasks are not to be disturbed. With batch drying, material handling and time are quite flexible, and small lot production is best suited for batch operation because of this extreme flexibility.

There is one school of thought in the food, and, to a lesser extent, in the chemical industry, that positive control over quality can be exercised only when manufacturing is done in batches. In the case of drying, this reasoning is fallacious since, within reason, the separation of batches can be accomplished even on a conveyor.

Intermittent or semi-continuous operation is a compromise between the conveyor and batch methods.

In selecting which of the foregoing three systems should be used, one should also establish, within reason, the reserve capacity of the drying system or provisions for its possible enlargement and the operating flexibility when handling different materials. Operating flexibility means shorter or longer drying time or the time the material remains in the dryer and the controllable range of temperature and humidity. Devices for safety, cleanliness and efficiency of operation, unless of utmost significance, do not need to be considered at this stage.

Regardless of the method used—continuous, intermittent, or batch—the drying operation should be uninterrupted from start to finish. In other words, shut-down over night or for minor repairs should be avoided by all means, inasmuch as the drying time will be unduly prolonged. First, the entire system and the material will have to be brought back to the working level; second, there may be duplication of drying efforts due to the material having absorbed or regained some of the moisture during the shut-down period.

This condition is especially pronounced in the case of batch dryers. Production schedules must be so arranged that either the dryer is left empty over night or, more desirable, no interruptions are to take place.

MECHANISM OF DRYING

Material Behavior During Drying

In drying we deal with and are able to remove only the free moisture, because the bound moisture content in a given material cannot be further reduced unless the conditions of surrounding air are altered. As can be observed from the shape of the curve in Fig. 2, this can be done either by reducing the humidity of the air without changing its dry bulb temperature, or by increasing the air temperature without necessarily lowering its absolute humidity. The latter method is much simpler and less expensive, provided the material is capable of withstanding higher temperature.

The physical significance of the unbound moisture in the material lies in the fact that it acts as plain water. It possesses all properties of ordinary water when exposed to various conditions of temperature and humidity; that is, it exerts full vapor pressure normal to water under the same conditions. Its removal from the material offers no undue difficulties and is usually very easy.

The vapor pressure of bound moisture is less than that of water under the same conditions. In what form it is retained in the material is not important from the evaporation point of view. It could be in the form of a chemical solution or pure water held in the capillaries, cells, or interstices of the material. The drying operation as a whole, however, may be governed to a considerable extent by the behavior of retaining media, if certain properties of material are to be preserved.

It will suffice to point out at this time that the *evaporation is directly proportional to the difference in vapor pressures of liquid in the material and that of the surrounding air.*

The vapor pressure of air is controllable and corresponds to its absolute humidity (saturation or dew-point temperature), whereas that of the bound moisture is not controllable and has to be carefully determined. The success of a drying installation producing hygroscopic goods at a predetermined rate and with a desired final moisture content depends to a great extent on the knowledge of this somewhat intangible vapor pressure of bound moisture. However, many materials requiring drying during their processing contain bound moisture in very small amounts and below the working range, thus greatly simplifying experimental work and drying computations.

The prime purpose of a drying process is the separation of liquids from solids by evaporation. Hence it is essential that the material should be supplied with the necessary amount of heat to convert liquid into vapor form and the liberated moisture be ejected. The temperature of the material undergoing drying is not necessarily representative of the rate at which it acquires heat. Some materials such as vaccines, plasma, etc., are kept at temperatures below freezing during the great part of the drying cycle.

Even in this extreme case, heat must be supplied and the liberated moisture in vapor form must be removed if the continuity of the process is not to be interrupted.

Determining Properties of Material

Essential design data on the material are obtained in a laboratory

or from previous experience. Even though a laboratory test is necessary, it may not necessarily be complex. A series of simple tests will yield sufficient information to formulate a hypothesis which can be further developed or disproved by another series of tests.

The procedure of conducting a drying test will vary with the nature of the material and the methods of heat supply and vapor removal selected. Generally speaking the test should consist of a log of the following readings:

Dry and wet bulb temperatures of air entering the dryer;

Dry and wet bulb temperatures of air leaving the dryer;

Quantities of circulated, make-up, and exhaust air;

Conditions of make-up and exhaust air;

Weight of material, perferably without removing the material from the dryer; and

Temperature of material surface and center.

Sometimes the nature of the material or of the method will make it impractical to take some of the foregoing readings, in which case some of them could be interpolated from others, but with caution. Observations of material appearance and behavior should also be made. Removal of unbound moisture is accomplished by evaporation, as evidenced by the corresponding reduction in weight. Removal of bound moisture involves internal moisture flow or the phenomenon of diffusion, and is accompanied usually by pronounced physical and chemical changes in the materials. Correct interpretation of these changes may lead to improving the drying cycle.

In the case of vacuum drying, removed moisture should be condensed and weighed at the same intervals of time; the vacuum pressure, vapor temperature and material temperature should be recorded, and, if possible, the rate of heat supply as well as of heat removal by the circulated condenser water, should be obtained.

A common error in many laboratory tests involves lack of data on make-up air. The test is conducted in winter and "standard" conditions of make-up air are used. For some unknown reason 70F dry bulb temperature and 50% relative humidity are used. In summer, the moisture content of make-up air taken from outside may be almost triple that of "standard" air, and as a result of this increased humidity the output of the dryer will either suffer or cease altogether.

Very often no record of conditions of make-up air is kept at all. Thus it is possible to conduct a drying test with a "dehumidified" air without duly acknowledging and recording this pertinent fact. One of the erroneously advanced arguments is the nominal effect the initial moisture content exercises on drying at elevated temperatures. This common error will be fully dealt with later.

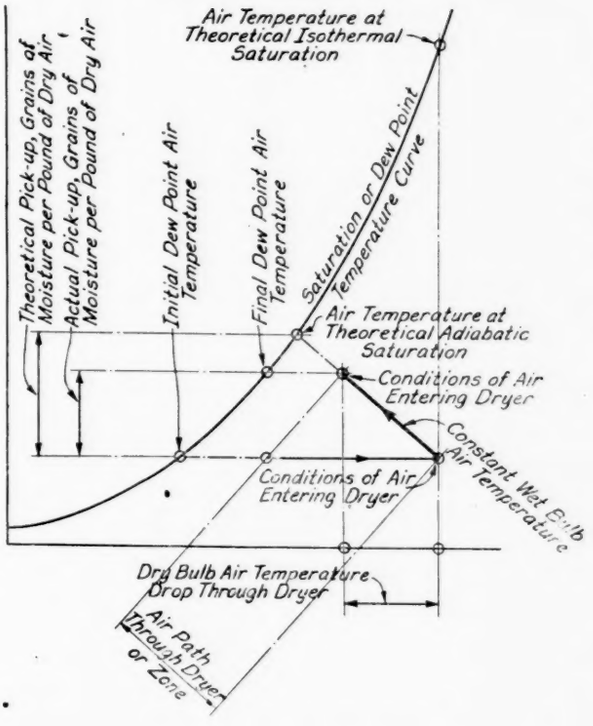

Air Temperature at Theoretical Isothermal Saturation
Theoretical Pick-up, Grains of Moisture per Pound of Dry Air
Actual Pick-up, Grains of Moisture per Pound of Dry Air
Initial Dew Point Air Temperature
Final Dew Point Air Temperature
Saturation or Dew Point Temperature Curve
Air Temperature at Theoretical Adiabatic Saturation
Conditions of Air Entering Dryer
Constant Wet Bulb Air Temperature
Conditions of Air Entering Dryer
Dry Bulb Air Temperature Drop Through Dryer
Air Path Through Dryer or Zone

Fig. 5. Progress of air through dryer plotted on a psychrometric chart.

Analysis of Laboratory Data

Graphical presentation of experimental data will result in conciseness and clarity. There are two basic drying curves. One of them is the *Drying Time Curve* (Fig. 3) and the other the *Drying Rate Curve* (Fig. 4).

The drying time curve is self-explanatory. The abscissa is time and the ordinate may be one of the following variables: weight of sample; moisture content, dry or wet basis; or percent weight of the sample, starting, naturally, with 100%.

Plotting the percent weight of sample could be combined on the same ordinate with the percent moisture content, wet basis, percent of volume of the sample, and the percent of free moisture removal, the latter starting at zero and becoming 100% at end of the drying process.

However, in order better to understand the drying operation and the moisture retaining properties of the material, the drying rate curve is used. This is a derivative of the drying time curve. The abscissa represents the moisture content, dry basis, or percent of free moisture, expressed as the ratio of weight of free water per weight of solids in the same sample. In the latter case, the final free moisture content upon conclusion of drying process should be equal to zero. The ordinate represents the relative or exact drying rate, the latter being expressed as the moisture removal per hour per square foot of exposed material surface or per square foot of dryer material holding surface.

In contrast to the drying time curve, the drying process as shown by the drying rate curve begins at the extreme right and terminates at the left. The drying rate curve accentuates the behavior of the material in comparison with that shown on a drying time curve.

Stages in Drying Process

The drying characteristics of the majority of hygroscopic materials can be grouped into four distinct stages, while the drying of other materials may consist of a smaller number of stages, due to the omission or combination of some of these stages. The breaking down of the drying process into stages is done, not for the sake of academic discussion, but to make it possible to design a drying system utilizing to the full advantage the known data on material behavior.

The four stages usually used are called the *adjustment stage* or heating-up period, the *constant drying rate stage*, unsaturated material surface or *uniform falling rate stage*, and the final *sub-surface drying stage*, sometimes is also called the varying falling rate period.

The approximate relation of stages to the moisture content in the material can be seen by comparison of Fig. 4 and Fig. 2. Inasmuch as the rates, rather than actual moisture losses, are involved, the drying rate curves present a very fertile ground for calculus. The practical value of such theoretical equations is negligible because there are always too many unknowns or experimentally

determined coefficients, constants, and limits present. If a test has to be run at all, it would seem desirable to simplify rather than complicate the problem and its solution.

The drying process starts at station 1 (Fig. 4). From station 1 to 2 the drying process may be decreased, remain constant, or increased, which is caused by the loss, no change, and acquisition of heat by the material, respectively. Thus from station 1 to 2 is the adjustment stage.

After the material temperature has been stablized the drying rate remains constant as shown by a horizontal line from station 2 to 3. This constant drying stage terminates when the surface of the material begins to dry out due to the fact that moisture could or is removed faster than it comes to the exposed surface. The drying rate begins to decrease and the start of this change corresponds to the critical moisture content of the material. The material temperature and moisture gradients can be fairly well established up to this point, depending upon the methods of heating and vapor removal.

From station 3 to 4 the drying rate is uniformly falling off and, hence, the name of this stage. As the name implies, the surface of the material is unsaturated or partially wet. The temperature of the material gradually increases, and there is present the danger of establishing too steep a temperature and moisture gradients between the surface and slab by overheating and overdrying the surface. During this stage both unbound and bound moistures could be removed and the establishment of a clean cut division line is rather difficult. The last stage starts at station 3 and terminates at station 4. During this last stage, the drying rate depends upon diffusion, or upon the rate of moisture flow from inside of the slab to its surface. As will be pointed out later only a nominal influence on this property of material can be exercised. The natural permeability of the cell membrane is the limiting feature. Improper drying may cause sealing of the membranes. The process of the moisture passage through the membrane is called *osmosis*. The term *diffusion*, in spite of its close relation to osmosis, should be used to designate the internal moisture flow through the slab of the material as a whole, rather than out of an individual cell.

Determination of the moisture content of a sample is very important. This matter has been well dealt with in numerous papers and will not be described herein. It should be pointed out, however, that the appearance, or "feel" of the material, is greatly misleading, sometimes even to those experienced on a repetitive operation, upon further receipt of heat, may violently escape by cracking and sometimes completely bursting the material into small pieces.

In concise terms, one best way to avoid difficulties is to maintain the entire slab of material at as uniform a temperature as possible throughout the entire drying process. Paradoxically enough, such a procedure may involve even the addition of surface moisture to the material at the start.

Evaporation occurs whenever the vapor pressure of the moisture in the material is greater than that of the vapor in contact with it. This does not necessarily mean "boiling." Boiling takes place whenever the liberated vapor possesses sufficiently high pressure to displace or literally push back all gases above it, be that air-water vapor mixture under atmospheric pressure, vapor in a vacuum, or steam under a positive pressure.

Thus in drying we deal with the differences rather than with the absolute vapor pressures. Throughout the entire operation, the drying rate could be controlled by the corresponding regulation of the vapor pressure difference, the limits being set by the regain and by the permissible material temperature. It must be understood however, that the magnitude of this difference is the force or the potential that causes drying, but it is not representative of the actual results either in terms of time or in terms of removed moisture.

THERMODYNAMICS OF DRYING

As the term implies, in evaporation the heat energy must be conveyed or generated in sufficient amounts to convert the liquid in the material into vapor, thus accomplishing the first phase of drying.

Excluding the effects of respiration or of fermentation of certain materials, heat is supplied from an outside source, and the vapor, after its escape from the material, is also handled as an independent medium. Thus, after the study of the mechanism of drying is completed, one can deal with the drying process from the point of view external to the material proper. Therefore, the thermodynamics of drying consists of the analysis of conditions external to the material proper, and the ultimate objective is the achievement of the maximum drying speed or, in other words, minimum drying time. However, one should never forget that the understanding of the material behavior undergoing drying process will point the shortest way to the most efficient drying cycle.

Drying speed depends to a considerable extent on the rate at which material acquires heat, which is not necessarily manifested by an increase in the temperature in the preliminary stages. The material temperature does rise upon loss of moisture and may eventually approximate that of the heat source.

To accelerate the outward migration of moisture, its vapor pressure should be kept as high as possible. Thus the temperature of the moisture in the material is of prime importance, whereas the temperature rise of the material proper may be considered purely incidental, though unavoidable. Hence, the maximum drying speed is achieved at the highest possible temperature.

It is the ability of the material proper to withstand the high temperature that determines the working level. The word ability may be loosely used to cover a multitude of sins or possibilities, namely physical spoilage due to the rupture of individual cells, cracking, warping, caking, shrinkage, and chemical or biological decomposition evidenced by the loss of desirable properties, discoloration, coagulation, and so on.

Emphatic distinction should be made here between the spoilage caused by excessive temperature and that due to use of improper drying methods or conditions. As an illustration of the latter, the overdrying of a surface will leave the inside impregnated with moisture which,

Methods of Drying

Heat can be supplied to the material in two basic ways. The first method consists of and involves heat transmission. In other words, the rate of heat flow is dependent upon the temperature difference between the source and the recipient. In the second case, known as electronic heating, no heat flow or transmission is involved at all, the heat being generated within the material and at a uniform rate throughout its entire bulk.

The first method is fairly well explored and is sub-divided into the orthodox conduction, convection, and radiation methods. The scope of the last has been greatly expanded in the past few years by the introduction of lamps and reflectors.

Drying operations, then, can be divided into four principal groups on a basis of heat applications, as follows:

1. Convection type, using preheated air circulation;

2. Radiation type, using radiant heating with forced air circulation or without it, as in a vacuum;

3. Conduction type, wherein material receives heat from a direct contact with a hot surface. Forced air circulation or vacuum could be employed in this case.

4. Electronic type, generating heat

in the material proper under vacuum or at atmospheric pressure. In the latter case air circulation could also be used.

At the present time the first group is the largest and the oldest. With the exception of vacuum drying, the air circulation always accompanies the heating process. Natural convection, thermally induced, is unavoidable. Radiation is also present to a greater or lesser degree.

CONVECTION DRYING

It is the purpose of this article to deal primarily with convection drying, and henceforth only this method will be considered. In convection drying air is used as the heat and vapor carrying medium. Circulated air is usually preheated prior to its contact with the material, but often heating of the circulated air and of the material is accomplished simultaneously by a combination convention-radiation type heater. In the latter case the temperature throughout the dryer is well equalized, and for this reason the name isothermal, meaning constant temperature, is assigned.

In convection drying, the vapor content of the circulated air is increased at a rate at which material gives up its moisture. It is thus said that air picks up moisture. This pick-up is usually expressed in terms of grains of moisture per cubic foot of circulated air, which may lead to a sizable discrepancy due to the fact that the volume of air laden with moisture varies considerably with the temperature and moisture content. Computations should be carried out therefore with absolute and unvarying weights of air rather than with widely fluctuating but convenient volumes.

Increase in the moisture content of air (expressed in terms of weight of saturated vapor per pound of dry air) signifies corresponding increase in its saturation or dewpoint temperature. Air and vapor existing at the dewpoint temperature are said to be saturated, and any reduction in temperature will cause some of this vapor to be condensed as water. Conversely, if the temperature is above that of saturation, the vapor is said to be superheated. Hence, in convection drying we always deal with superheated vapors, the degrees of superheat being the difference between the dry bulb and dewpoint temperatures.

For all practical purposes, there is no limit how high the air can be heated. Pure air can be economically heated and delivered to a dryer at a temperature of 1000F. There is, however, a definite limit as far as the saturation temperature of air is concerned.

Saturated steam at 212F exerts full atmospheric pressure, occupies a specific volume of 26.8 cu ft per lb, and has a total heat content of 1,150 Btu per lb. It is impossible to alter any of the above conditions without affecting the others. Saturated steam exerting full atmospheric pressure can exist in complete absence of air. Atmospheric pressure is the summation of air and of vapor or steam pressures. Presence of even a small quantity of air will displace some of the steam and cause corresponding reduction in the steam pressure or in the pressure of the saturated vapor present.

It is impractical to exclude air totally or to an appreciable extent from spaces other than completely sealed chambers, such as boilers, evaporators, or condensers. A dryer, not being a completely enclosed vessel, will always contain some air. Therefore, we can conclude that: Saturated air cannot exist at temperatures in excess of 212F and, in reality, can only approach this limit; by its definition, the relative humidity of air also loses all of its significance at dry bulb temperatures in the vicinity and in excess of 212F; and wet bulb temperatures, regardless of how high the dry bulb temperature may be, can also only approximate and never exceed 212F.

Thus we have established the upper limit of the working range when dealing with moisture. Measured in degrees of dewpoint or saturation temperature, this working region is very small. A variation of ten degrees or so in the dry bulb temperature will not substantially affect drying computation or performance, whereas the difference of only a few degrees in the dewpoint temperature will represent a substantial portion of the available margin.

As previously mentioned, air picks up moisture in passing over the material. The amount of this actual pick-up is proportional to the theoretical ability of air to absorb additional moisture. Saturation of air will indicate the attainment of the maximum possible utilization; therefore, preheated air can theoretically pick-up a maximum quantity of moisture represented by the difference in its initial and final (saturation) moisture contents.

After the first adjustment stage during which both the material and the dryer came up to the working temperature, the only heat losses from the dryer are those of radiation and conduction from its housing. The circulated air does not give up any appreciable quantity of heat, and its heat content remains practically unaltered during its contact with the material. This is manifested by a constant wet bulb temperature. The convection drying by preheated air is in reality a heat conversion process in that the sensible heat in the air is converted into the latent heat of vapor which in turn becomes a component part of the circulated air.

These dryers are called adiabatic or constant heat content dryers. Fig. 5 shows on a psychrometric chart the progress of air through the dryer. The theoretical ability of air to increase its vapor content, shown on the same chart, has been called *grain deficiency*, *theoretical pick-up*, *drying potential*, and *theoretical absorption*. The best term is probably theoretical pick-up expressed in grains of saturated vapor per pound of dry air. Full margin is never utilized in practice because the presence of saturated air will tend to slow down the process. Possible exceptions are the high humidity heating-up stage and the flash-off dryer both operating at moderate temperatures. The latter, in a final analysis, is also a high humidity treating chamber and not a complete dryer, as the bulk of the moisture is removed from the material upon leaving it.

In adiabatic drying the magnitude of the theoretical pick-up is approximately equal to the difference between the moisture content of air saturated at the supply wet bulb temperature and the initial moisture content of the same supply air. For example, if the dry and wet bulb temperatures of supply air are 180F and 100F respectively, the corresponding dewpoint temperature is 81F, and the initial moisture content is 161 grains per pound of dry air. At 100F dewpoint temperature, air contains 301 grains of moisture. Hence, the theoretical pick-up is equal to $301 - 161 = 140$ grains per pound of dry air.

The ratio of the actual to the theoretical pick-up is called *percent pick-up* and this is where the drying stages and the material handling exercise controlling influence. The percent pick-up is seldom above 75% and may be as low as 10%, depending upon a number of variables. By proper selection of the dryer type—i.e., of the method of bringing the material in contact with the air, permissible rates of air circulation, utilization of progressive drying taking full advantage of the previously observed material behavior during drying, and, last but not least, by properly preparing the material—the percent pick-up can be determined and controlled.

Extent and type of preparation will, of course, vary with the characteristics of material. Typical examples are preheating, preforming, extrusion, rolling, granulating and freezing. Preconcentration by the removal of certain quantities of unbound moisture could also be accomplished by gravitational or by mechanical pressure means such as centifuges, filters,

presses, etc. Thus the material preparation, handling, and the method of heating are closely interrelated.

Heat economy can be achieved not only by increasing the percent pick-up but also by elevating the working humidity level as high as possible. In other words, the dewpoint temperature of exhaust air should be maintained at a maximum, provided this will not retard the drying speed.

Very often the quantity of exhaust air is reduced and its moisture content is correspondingly increased. Due consideration must then be given to see that drying speed is not impaired; that final desired moisture content is reached; and that dryer construction permits the maintenance of high humidity (that is, that no condensation of vapor and no undesirable leakage of air laden with moisture or fumes from the dryer will take place).

Zoning

Progressive increase in the absolute humidity of air is effected by various means, the simplest being the use of counter-current flow. More efficient, though more expensive, is the division of a drying system into two or more zones. Each zone has its own air handling and air treating apparatus and is independently controlled.

The zone operation is coordinated and the exhaust from one zone is used as a make-up air for the next zone. A simplified example of a multi-zone operation follows:

Example: Maximum supply air temperature—200F in all zones. Design dewpoint temperature in summer—71F (saturated air). Unit drying duty — 230,000 grains of unbound moisture per minute. Percent pick-up — 35% in all zones. Latent heat of steam — 930 Btu per pound.

Neglect heat losses of circulated air; in other words, assume the maintenance of a constant wet bulb temperature throughout each zone; no recirculation of air is permissible; disregard air leakages.

Solution: In the solutions which follow the drawings are used to bring out more clearly exactly what is happening and to show the conditions with which each of the four separate problems is entered. Bear in mind that air in passing through a steam heater has its dry bulb and wet bulb temperatures changed but its dewpoint remains constant; in the dryer the dry bulb temperature drops and the dewpoint temperature, an indicator of latent heat, rises, while the wet bulb, indicating total heat, remains unchanged.

Single Zone Dryer

Air at 71F dewpoint when heated to 200F has (from the psychrometric chart) a wet bulb of 98.5F
Saturated air at a wet bulb of 98.5F contains ..... 286 gr. per lb of dry air (leaving dryer)
Air at 71F dewpoint contains ..... 114 gr. per lb of dry air (entering dryer)

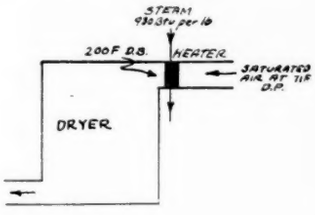
Theoretical pick-up ..... 172 gr. per lb of dry air
Actual pick-up .35 × 172 = ... 60 gr. per lb of dry air

$$\text{Required air flow to pick up 230,000 gr.} = \frac{230{,}000 \text{ Btu per min}}{60 \text{ gr. per lb of dry air}} = 3830 \text{ lb of air per min}$$

Heat in air leaving heater, 98.5F w.b. ..... = 68.8 Btu per lb dry air
Heat in air entering heater, 71F d.b. ..... = 34.8 Btu per lb dry air

Heat added by heater ..... = 34.0 Btu per lb dry air
Total heat added by heater = 3830 lb of air per min × 34 Btu per lb dry air = 130,220 Btu per min

$$\text{Steam required} = \frac{130{,}220 \text{ Btu per min}}{930 \text{ Btu per lb steam}} = 140 \text{ lb steam per min}$$



Air entering dryer contains ..... 114 gr. per lb of dry air
Actual pick-up ..... 60 gr. per lb of dry air

Air leaving dryer contains ..... 174 gr. per lb of dry air and has a w.b. of 98.5F
Air leaving dryer, from psychrometric chart, is at 163F dry bulb, 83.3F d.p.

Double Zone Dryer

From the psychrometric chart, air at 163F d.b. and 83.3F d.p. heated to 200F has a wet bulb of 104F.
Saturated air at 104F w.b. contains ..... 341 gr. per lb dry air
Air at 83.3F d.p. contains ..... 174 gr. per lb dry air

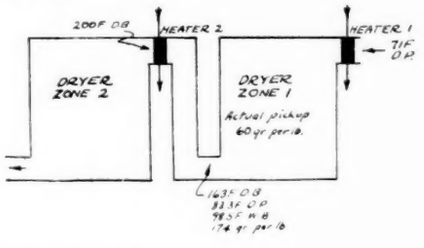
Theoretical pick-up = ... 167 gr. per lb dry air
Actual pick-up = .35 × 167 = 58.5 gr. per lb dry air
Total pick-up of zones 1 and 2 = 60 + 58.5 = 118.5 gr. per lb dry air

$$\text{Required air flow} = \frac{230{,}000 \text{ gr. per min.}}{118.5 \text{ gr. per lb dry air}} = 1945 \text{ lb air per min.}$$

Heat in air leaving heater 2 (104F w.b.) = 78.9 Btu per lb air
Heat in air entering heater 1 (71F d.p.) = 34.8 Btu per lb air
Heat added by heaters = 44.1 Btu per lb air

Total heat added by heaters = 1945 lb air per min × 44.1 Btu per lb air = 85775 Btu per min.

$$\text{Steam required} = \frac{85775 \text{ Btu per min.}}{930 \text{ Btu per lb steam}} = 94 \text{ lb per min.}$$



Air entering zone 2 contains ..... 174 gr. per lb of dry air
Actual pick-up, zone 2 = ... 58.5 gr. per lb of dry air

Air leaving zone 2 contains ..... 232.5 gr. per lb of dry air and has a wet bulb of 104F
Air leaving zone 2, from psychrometric chart, is 163F d.b. and 92F d.p.

Triple Zone Dryer

From the psychrometric chart, air at 163F d.b. and 92F d.p., heated to 200F has a wet bulb of 108.5F
Saturated air at 108.5F contains ..... 394 gr. per lb dry air
Air at 92F d.p. contains ..... 232 gr. per lb dry air

Theoretical pick-up = ... 162 gr. per lb dry air

Actual pick-up .35 × 162 = 56.5 gr. per lb dry air

Total pick-up of zones 1, 2 and 3 = 60 + 58.5 + 56.5 = 175 gr. per lb dry air

$$\text{Required air flow} = \frac{230{,}000 \text{ gr. per min.}}{175 \text{ gr. per lb dry air}} = 1315 \text{ lb air per min.}$$

Heat in air leaving heater 3 (108.5F w.b.) = 88.4 Btu per lb air
Heat in air entering heater 1 (71F d.p.) = 34.8 Btu per lb air

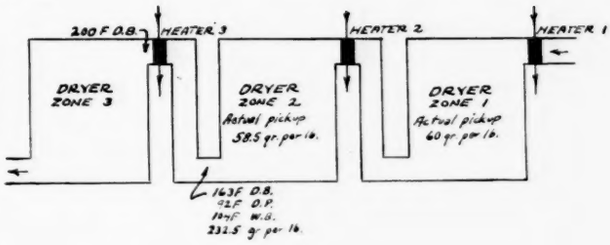
Heat added by heaters = 53.6 Btu per lb air

Total heat added by heaters = 1315 lb air per min × 53.6 Btu per lb air = 70,484 Btu per min.

$$\text{Steam required} = \frac{70484 \text{ Btu per min.}}{930 \text{ Btu per lb steam}} = 76 \text{ lb steam per min.}$$

Air entering zone 3 contains 232.5 gr. per lb air
Actual pick-up, zone 3 58.3 gr. per lb air

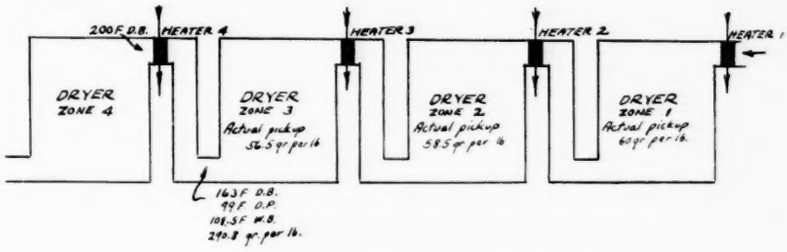
Air leaving zone 3 contains 290.8 gr. per lb air and has a wet bulb of 108.5F
Air leaving zone 3, from chart, is at 163F d.b. and 99F d.p.



Quadruple Zone Dryer

From the psychrometric chart, 163F d.b. 99F d.p. air heated to 200F has a wet bulb of 112F
Saturated air at 112F contains 440 gr. per lb dry air
Air at 99F d.p. 290.8 gr. per lb dry air

Theoretical pick-up, zone 4 = 149.2 gr. per lb dry air
Actual pick-up, .35 × 149.2 = 52.4 gr. per lb dry air



Total pick-up of zones 1 to 4 = 60 + 58.5 + 56.5 + 52.4 = 227.4 gr. per lb dry air

$$\text{Required air flow} = \frac{230{,}000 \text{ gr. per min.}}{227.4 \text{ gr. per lb air}} = 1010 \text{ lb of air per min.}$$

Heat in air leaving heater 4 (112F w.b.) = 96.7 Btu per lb air
Heat in air entering heater 1 (71F d.p.) = 34.8 Btu per lb air

Heat added by heaters = 61.9 Btu per lb air

Total heat added by heaters = 1010 lb air per min. × 61.9 Btu per lb air = 62,519 Btu per min

$$\text{Steam required} = \frac{62519 \text{ Btu per min.}}{930 \text{ Btu per lb steam}} = 67 \text{ lb steam per min.}$$

Air entering zone 4 contains 290.8 gr. per lb air
Actual pick-up, zone 4 52.4 gr. per lb air

Air leaving zone 4 contains 343.2 gr. per lb air and has a wet bulb of 112F
Air leaving zone 4 has a dewpoint of 104F, and a d.b. temperature of 163F

The foregoing and a unit performance rate based on them are shown in table below.

Examination of these data will show the decided economy of two or possibly of three zones, but the further gain will not likely justify the installation of the fourth zone. Obviously the lower steam consumption is offset by the higher first cost.

For the sake of convenience, the assumption was made that the reduced air velocity caused by the decrease in the air circulation will not adversely affect the pick-up. This is not always the case, and in order to maintain the pick-up additional quantities of air may be locally recirculated in each zone, thus maintaining the velocity and the uniformity of heating. Corresponding corrections must then be made in the computations.

The detailed explanation of each step shown in the example are not necessary in practice. In order to keep all data and calculations in a clear and concise form, the writer devised and used for many years the air flow and heat balance chart shown in Fig. 6 and which applies to the previous example. Detection of errors, comparison of different cycles, and the determination of capacities of various component apparatus items as well as their location are greatly facilitated. It is also possible on a single sheet to make a summary and use it as a check of the actual performance of any air system, be that a high or low temperature drying, air conditioning, refrigeration, or heating installation.

The importance of using absolute units such as pounds of air and grains per pound of air instead of relative units such as cubic feet of air and grains per cubic foot becomes self-evident on this chart.

The seeming discrepancy caused by the use of relative units is aggravated when greater temperature dif-

Zone	Steam Consumption Rate Pounds per Hour	Relative Performance Rates	
		Per Cent	Pounds of Steam per Pound of Water Removed
1	8,400	100	4.25
2	5,600	67	2.84
3	4,560	54	2.32
4	4,020	48	2.04

FIG. 6. AIR FLOW AND HEAT BALANCE CHART FOR 4-ZONE DRYER.

DATA	STATION NO. 1	2	3	4	5	6	7	8	9
Dry bulb temperature, F	71	200	163	200	163	200	163	200	163
Wet bulb temperature, F	71	98.5	98.5	104	104	108.5	108.5	112	112
Dewpoint temperature, F	71	71	83.3	83.3	92+	92+	99—	99—	104+
Heat content, Btu per lb air	34.8	68.8	68.8	78.9	78.9	88.4	88.4	96.7	96.7
Moisture content, grains per lb air	114.2	114.2	174	174	232.5	232.5	290.8	290.8	343.2
Air flow, lb per min	1010	1010	1010	1010	1010	1010	1010	1010	1010
Specific volume, cu ft per lb air	13.71	17.0	16.5	17.3	16.6	17.5	16.9	17.75	17.1
Air flow, cfm	13800	17150	16650	17450	16750	17600	17050	17900	17250
Moisture content, grains per cu ft	10.3	8.35	10.5	10.1	14.0	13.3	17.1	16.3	20.0
Percent theoretical pick-up		35		35		35		35	

Steam Consumption:

From one to two = $(68.8—34.8) \frac{1010 \times 60}{930} = 2{,}210$ (Heater 1)

From three to four = $(78.9—68.8) \frac{1010 \times 60}{930} = 657$ (Heater 2)

From five to six = $(88.4—78.9) \frac{1010 \times 60}{930} = 617$ (Heater 3)

From seven to eight = $(96.7—88.4) \frac{1010 \times 60}{930} = 540$ (Heater 4)

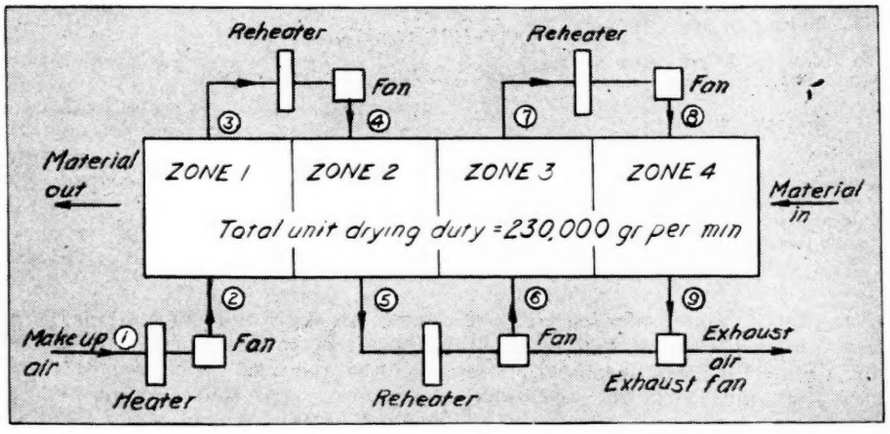
Total steam consumption, lb per hr = 4,024

Drying Data:

Station 2 to 3 = (174—114.2) 1010 = 60,600
Station 4 to 5 = (232.5—174) 1010 = 59,100
Station 6 to 7 = (290.8—232.5) 1010 = 58,900
Station 8 to 9 = (342—290.8) 1010 = 52,900

Total unit drying duty, grains per min of 1,980 lb water per hr = 231,500

$\frac{4{,}024}{1{,}980} = 2.04$ lb steam per lb water



ferences are present. It is quite possible erroneously to show a reduction in the moisture content between two stations instead of an increase if moisture is expressed in terms of grains per cubic foot of air at prevailing conditions.

In the example, the theoretical pick-up remains practically constant regardless of the absolute humidity. This produces a tendency to ignore the necessity of exact determination of the working humidity levels, first by fixing and then by keeping at a minimum the quantity of make-up air throughout all seasons of the year, and, going a step further, completely abandoning all humidity controls or indicators. The factors limiting such a practice were outlined previously. The main incentive is the reduction in the initial cost and the attaining of a highly questionable operating "economy."

The modern dryer must be a full-fledged production machine. Vagaries of weather cannot be allowed to control the performance of any well designed dryer. Therefore, the drying conditions, once determined, must be maintained if the production is not to vary or suffer. It should also take approximately as long to dry a batch of a given size in summer as in winter, all other material data remaining unaltered.

Incidentally, in air conditioning practice the characteristics of air supplied to the space are regulated to compensate for the variations in the imposed heat and moisture loads. The term "maintained conditions" is used to designate the desired characteristics of air in the space, the true average being established near the return air opening or in the return air duct.

In drying practice, either the supply or the return air characteristics may be under control. Continuous dryers are usually controlled from the return air, whereas batch dryers may be controlled from either the return or the supply. The latter is used to prevent overheating of the material and to make it possible to operate adjacent compartments of the same batch dryer without upsetting each other, provided air flow is in parallel and not in series. Unless otherwise stated, in the remainder of this article, the conditions maintained in the dryer will be assumed to be those in the return air duct.

The bulk of inorganic materials having very low regain can be dried at high absolute humidities. In such cases, the absolute humidity in the dryer is kept above the possible maximum humidity of outside summer air. Whenever additional moisture is absorbed by the air from the material, the humidity will be increased unless some of the air is spilled or exhausted and an equivalent amount of outside air be introduced. The rate of air circulation through the dryer will remain con-

stant, whereas the relative amounts of the exhaust, recirculated, and make-up air will vary depending upon the dewpoint temperature of outside make-up air and the rate of drying. The simplest way to insure unvarying performance is automatically to position three interconnecting dampers in the make-up, recirculated, and exhaust air duct in response to the demand of the humidity controller. Percent of air recirculation may vary from zero in summer time and close to a unity in winter or at the start of a drying operation.

Dehumidifying

Depending upon regain (always assuming a maximum permissible temperature), dehumidified air may have to be used. What apparatus or devices are used to dehumidify air is immaterial, as long as the requirements are met. Either well-water, power-driven refrigeration, vacuum water vapor systems, physical adsorption, chemical absorption, or melting of ice can be utilized to remove the moisture from air. The selection of the method must be governed not only by the involved economics, but also by the extent of the dehumidification—final moisture content, quantity, and temperature of air leaving the dehumidifying apparatus. The determined quantity of air to be humidified can be taken in any relative amounts from outdoors, return air duct, or locally recirculated. Its introduction into the cycle should be modulated to meet the demand of the humidity controller.

Cost of dehumidified air is high, especially when low humidities are involved. Therefore, it is advisable first to ascertain its necessity, and second, to establish the relation between the regain and time it takes to reach it. Time is ignored in establishing the regain, and it is said that the material reaches equilibrium with the surrounding air when no further changes take place. In practice, to achieve the final desired moisture content in the shortest time, the regain conditions are used as a guide, instead of as exact data, for design.

In the final stage of drying the theoretical pick-up must be established just the same as in any other stage, and the best way to correlate the magnitude of the drying potential, regain data, and time is to run a simple test.

Many materials cannot withstand prolonged exposure to even moderate temperatures without deterioration. Throughout the greater part of and in some instances throughout the entire year, their drying cannot be effected at all. In these cases, use of properly dehumidified and possibly cooled air will insure uniformity of production. One should remember, however, that regardless of the working temperatures and humidity levels, the theoretical pick-up should be maintained within practical limits, otherwise either the rate of air circulation will become excessively high or the drying speed will suffer.

Spray drying is a specialized form of the adiabatic convection principle of moisture removal. Preparation and handling of material result in an extremely large exposed area, thus facilitating heating and diffusion. Because of a very short drying time, use of high air temperatures does not result in excessive final material temperature. Spray drying is cited here as a vivid illustration of the value of time.

COMPLETE SOLUTION OF PROBLEM

Possibly the best way to illustrate the significance of the theoretical and experimental work is to take an actual example and to carry it out. The drying of ceramic powder will be used. For the sake of brevity, only essential data need to be considered.

Example

Production Requirements. The production rate is 900 lb of dry ceramic powder per hour on a continuous basis, using as a heating medium steam at 25 lb per square inch, gage.

Material Data. The material is granular, consisting mostly of talc. It has a specific heat of 0.22, dry, a specific weight of 98 lb per cubic foot, wet material. Initial moisture content is 19%, wet basis, and final moisture content ½ of 1% maximum, wet basis. The material is capable of withstanding high temperature, but the granular form should be preserved. Material shrinkage can be neglected in drying. The hygroscopic properties of material closely approximate those of clay, a fact fairly well established by the plant chemists.

Previous Practice. Powder was dried on trays, ¾ in. to 1 in. deep, in batch dryers, using natural convection of products of combustion of city gas. The average drying time was 24 hours, the temperature near the gas burners on the lower shelf was approximately 250F, while the exhaust air temperature varied from 120 to 220F.

Only vague data were available on the continuous drying of the powder on canvas belts at 350F. This homemade dryer was previously dismantled because of the short life of belts and because of the contamination of powder by the lint coming off the belts. However, forced air circulation was used. The drying time was about one hour, and the final moisture content was satisfactory.

Solution

The first step was to obtain further information about talc. Talc is a popular name for soapstone which belongs to a family of metasilicates and its chemical formula is $H_2Mg_3(SiO_3)_4$. Its neighbor is asbestos with a formula $CaMg_3(SiO_3)_4$. No regain or moisture equilibrium data could be found in any available references for talc. To conduct a series of lengthy regain determination tests was out of the question because of the rush nature of the job.

Quick action was necessary, and it was decided to base the computations on the ample data for various clays. Unfortunately, all tables and curves pertained to 75 or 85F dry bulb temperatures and while they clearly established equilibrium conditions, the reaction rate or the time element was ignored. Thus it became obvious that a lot of interpolation for higher temperature would be required. The following procedure was followed:

Evaporation depends upon vapor pressure difference of the moistures in the material and of that in the air. The vapor pressure of unbound moisture in the material corresponds, in the initial drying stages, to that of the wet bulb temperature of circulated air because of evaporative cooling, and in the final stage corresponds to the temperature of the material proper. From the available regain information it was established that at ½ of 1% moisture content, dry basis (practically the same on the wet basis), the remaining bound moisture (below the equilibrium moisture content curve) exercised at equilibrium a vapor pressure approximately 0.7 of an inch of mercury less than that in the surrounding air.

This was determined by looking up in the tables the vapor pressure corresponding to the material temperature and subtracting from it the vapor pressure corresponding to the dewpoint temperature of the surrounding air.

Then it was assumed that as long as this potential of 0.7 in. mercury remained, the desired moisture content would be achieved. To provide an additional factor of safety and to accelerate the reaction rate, it was further assumed that the bound moisture would remain at the wet bulb temperature of the circulated air, rather than approaching that of the powder. This unscientific pro-

cedure was subject to criticism, but a simple test verified the hypothesis.

Selection of the Dryer Type. The powder was inorganic, non-combustible, and non-explosive, but abrasive in nature. Dust and abrasion are highly undesirable, and for these reasons the number of bearings, pivots and other moving parts had to be kept to a minimum. The idea of using a rotary drum dryer was rejected not so much because of dust, which could have been eliminated by proper dust collecting means, but because of breaking up the granulations.

Hinged trays or aprons attached to a conveyor chain were also condemned because of abrasion and loading difficulties. Thus a solid belt seemed the best solution. Swedish flexible steel was not available, and the choice narrowed down either to canvas or rubber. Both of these materials, it was thought, would be unable to withstand continuous exposure to temperatures in excess of 140F. Although the manufacturers of the rubber belts estimated the life not to exceed nine months, due to the previous experience with canvas belts the decision was made in favor of rubber. Thus the drying conditions had to be adjusted to suit the material handling, and the dry bulb temperatures of the circulated air had to be kept as low as practically possible to prolong the belt life.

To reduce the physical size of the dryer housing and periodically to expose fresh layers of powder to air, a multiple-belt arrangement, with belts traveling in opposite directions and one above another, was used. To make it a straight line flow, an odd number of belts was necessary.

Drying Computations. The first step was to determine the unit drying duty. The assumption was made that with good air distribution the drying time could be cut from one hour in the old dryer to not more than 45 minutes in the new installation.

The moisture removal was computed as follows:

Final weight, 900 lb per hr.
Solids, or bone dry weight, 99½% wet basis, or 895.5 lb.
Final moisture weight, ½ of 1% wet basis, or 4.5 lb.

The initial and the final weight of solids are equal, but in the initial state of material, solids represent only 81%. Therefore, the initial weight of material is equal to 895.5 divided by .81 or 1,105.5 lb. Hence the moisture removal is equal to 1,105.5 minus 900, or 205.5 lb of moisture per hour. As a check, 19% of 1,105.5 is 210 which, less 4.5, will result in 205.5 lb. The unit drying duty is equal, therefore, to 205.5 lb x 7,000 (gr. per lb) and divided by 60 (min per hr) or to 24,000 grains of moisture per min.

The second step was to establish the maximum permissible air circulation; maximum so as to keep the temperature down. Next to the blow-through type of air circulation, perpendicular air flow in relation to the material is most effective. Relatively fine powder at rest will not be disturbed by a right angle air velocity of 50 ft per min or by a parallel air flow of 110 ft per min. From previous experience with somewhat similar materials, a loading of the belt with a layer of material not exceeding ½ in. was used. The following computations are self-explanatory:

Dryer holding capacity of material = 900 lb x .75 hours = 675 lb dry, or 1,105.5 lb x .75 hours = 830 lb wet. This is equivalent to (830 lb divided by 98 lb per cu ft) = 8.45 cu ft of wet material.

A 48 in. wide rubber belt was loaded to 42 in. width and ½ inch depth, or one lineal foot of belt carried (42 times ½ times 12 and divided by 1,728) = 0.146 cu ft of wet material, or 14.3 lb. Therefore, the total required effective belt length and effective belt area in the dryer were 58 lineal ft and 222 sq ft, respectively. Thus, with three passes, each belt should then be 19.4 feet long, and the belt speed approximately one foot per minute. Finally, the maximum permissible air circulation was determined to be 11,100 cu ft, hot volume, per min (222 sq ft times 50 cu ft per sq ft).

Having determined the approximate dimensions of the dryer housing (say 25 ft long, 8 ft wide, and 7 ft high) and the rate of air circulation, the next step was to correlate the unit drying duty, rate of air flow, and previously established regain data, keeping in mind the desirability to adhere to low temperatures.

Thermodynamics of Drying. The starting point was to ascertain the probable moisture content of make-up air, similar to the design conditions in summer used in air conditioning practice. Because of expense, use of dehumidified air was not desirable. Weather data indicated that 72F dewpoint temperature (ignoring the dry and wet bulb temperatures) was a reasonable maximum for the location of the plant.

From psychrometric tables, 72F dewpoint temperature corresponds to 0.79 in. of mercury vapor pressure, 118.2 grains per lb of dry air, and at saturation the heat content is 35.7 Btu per lb of dry air.

To insure continuous production throughout the year, the 72F dewpoint temperature was accepted as the design condition; that is, the computations were based on the fact that the minimum moisture content of make-up air will be 118.2 grains per lb of air.

11,100 cfm, hot volume (previously decided as maximum volume), was assumed on the first try to be equal to 675 lb of air (16.5 cu ft per lb).

Each pound of air therefore will be required to pick up 35.6 grains (24,000 gr. moisture per min divided by 675 lb air per min). With no recirculation in summer time, the final or the maintained dewpoint temperature will become 79.5F, corresponding to a moisture content of 153.8 grains per lb of air (35.6 plus 118.2), and the corresponding vapor pressure will be 1.0 in. of mercury. The maintained wet bulb temperature then becomes 96F (corresponding to a vapor pressure of 1.0 in. plus 0.7 in. of mercury) and the accompanying dry bulb temperature will be about 162F. Neglecting heat losses, the supply air dry bulb temperature must be 15 to 20F above 162F or, say, in the vicinity of 185F. The theoretical pick-up will be 146 grains per lb (264 grains per lb at 96F minus 118 grains per lb at 72F), and the percent pick-up will be 24% (35.6 gr. per lb divided by 146 gr. per lb) which is somewhat low for this type of air distribution. The steam consumption will be 1,260 lb per hour (64.6 per lb air at 96F minus 35.7 per lb air at 72F, times 675 lb of air per min, times 60 min per hr, and divided by 933 Btu latent heat per lb of steam), corresponding to over 6 lb of steam per lb of removed moisture (1,260 lb steam per hr divided by 205 lb of moisture per hr), which seems high, or the thermodynamic efficiency is too low.

To improve efficiency of heat utilization, one should try, as previously narrated, cutting down the quantity of exhaust air, or to resort to air recirculation. Highly unscientific, but practically effective, the rule of thumb suggests the starting point of 50% recirculation. The procedure then is as follows:

The liberated moisture will be removed from the dryer by the exhaust air only. The difference in the initial and final moisture content of exhaust air times the rate of its flow must be equal to the unit drying duty.

With 50% air recirculation, the rate of flow of the exhaust and make-up air will be 337 lb per min (675 lb air per min divided by 2). The moisture pick-up per pound of primary (exhaust or make-up) air will be 71.2 grains (24,000 gr. moisture per min divided by 336 lb air per min), and the final or the maintained dewpoint temperature will be about 86F corresponding to a moisture content of 189.4 grains (71.2 gr. per lb air plus 118.2 gr. per lb air). The vapor pressure maintained in the dryer is then 1.25 in. of mercury and the required maintained wet bulb temperature will be about 100F (1.25 plus 0.7 equal to 1.95 inches of mercury). With 100F wet bulb temperature and 86F dewpoint temperature, the maintained dry bulb temperature

will be 163F. The actual pick-up per pound of circulated air will remain the same, namely 35.6 grains per lb air, and the initial moisture content of circulated air will be 153.8 grains per lb (189.4 gr. per lb air minus 35.6 gr. per lb air).

Neglecting heat losses, then, the initial conditions of circulated air will be 187F dry bulb, 100F wet bulb, and 79.5 dewpoint temperatures. The theoretical pick-up is 146 grains per lb (300 gr. per lb air at 100F minus 154 gr. per lb air at 79.5F) so that the percent pick-up is again 25% (35.6 gr. per lb air divided by 146 gr. per lb air). The steam consumption will be approximately 775 lb per hour (71.4 Btu per lb air at 100F minus 35.7 per lb air at 72F, times 337 lb air per min times 60 min per hr, and divided by 933 Btu latent heat per lb of steam), corresponding to 3.75 lb of steam per lb of removed moisture (775 lb steam per hr divided by 205 lb of moisture per hr), which, in spite of a still low percent pick-up, represents improved heat utilization.

Further increase of recirculation may cause condensation in the dryer and may result in the increased dry bulb temperature of supply air, which would be undesirable.

Previous experience, however, indicated that the average percent pick-up for the proposed air distribution should be in the vicinity of 35%. The following procedure is followed to use a predetermined pick-up as the basis of computations. Theoretical pick-up in the foregoing case should be 102 grains per lb air (35.6 gr. per lb air divided by 0.35). With 50% recirculation, the initial moisture content of circulated air is 153.8 grains per lb of air. Neglecting heat losses and to meet the requirements of 35% pick-up, the wet bulb temperature of supply air should be 94.5F corresponding to a theoretical pick-up of 102 grains per lb air (102 gr. per lb air plus 153.8 gr. per lb air is equal to 255.8 grains per lb air, or 94.5F).

However, the vapor pressure differential will be only 0.41 in. of mercury (1.63 inches at 94.5F minus 1.22 in. at 85F).

Therefore both requirements of percent pick-up and vapor pressure differential could not be fulfilled within this range of dry bulb temperature.

In the original assumption, the wet bulb and dew point temperatures maintained were used for computation of this differential. However, the air coming in contact with the powder possesses higher differential, and as a compromise all way round, it was decided to use the average of supply and maintained conditions. Because of the previously mentioned additional factor of safety and because of the possibility of further increasing the thermodynamic effi-

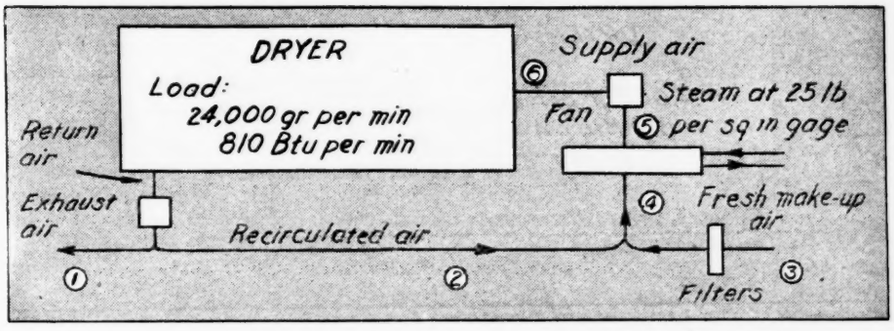


FIG. 7. AIR FLOW AND HEAT BALANCE CHART FOR CERAMIC POWDER DRYER—SUMMER CYCLE

DATA	STATION NO. 1	2	3	4	5	6
Dry bulb temperature, F.....	154	154	72	120	190	180
Wet bulb temperature, F.....	99+	99+	72	90—	101	100
Dewpoint temperature, F.....	87—	87—	72	81+	81+	81+
Percent relative humidity.....	16	16	100	32	6	7
Total heat, Btu per lb air.....	70.3	70.3	35.7	55.5	73.2	71.4
Moisture content, grains per lb air	195.7	195.7	118.2	162.4	162.4	162.4
Specific volume, cu ft per lb air..	16.45	16.45	13.75	15.2	18.0	17.9
Airflow, lb per min.....	310	410	310	720	720	720
Airflow, cfm	5100	6750	4250	10950	13000	12900
Moisture content, grains per cu ft.	11.9	11.9	8.6	10.7	9.0	9.1
Vapor pressure, in. mercury.....	1.28	1.28	.79	1.08	1.08	1.08

$\frac{24000}{310}$ = 77.5 gr. per lb fresh air

77.5 + 118.2 = 195.7 gr. per lb return air

$\frac{24000}{720}$ = 33.3 gr. per lb pick-up

195.7 — 33.3 = 162.4 gr. per lb supply air*

Vapor pressure at 100F = 1.93 in. mercury
at 81F = 1.08

Initial difference in vapor pressure = .85 in. mercury

Vapor pressure at 99F = 1.89 in. mercury
at 87F = 1.28

Final difference in vapor pressure = .61 in. mercury

Average vapor pressure = $\frac{.85 + .61}{2}$ = .73 in. mercury

At station four:

310 × 35.7 = 11,080

410 × 70.3 = 28,820

39,900 Btu per min, in mixture

$\frac{39900}{720}$ = 55.5 Btu per lb air

310 × 118.2 = 36,700

410 × 195.7 = 80,300

117,000 gr. per min, in mixture

$\frac{117000}{720}$ = 162.4 gr. per lb air*

Percent pick-up: At 99F+, moisture = 293 gr. per lb

At 81F, moisture = 162.4 gr. per lb

Theoretical pick-up = 131 gr. per lb

Percent pick-up = $\frac{33.3}{131}$ = 25.5%

Total heat demand = (73.2 — 55.5) 720 × 60 = 765,000 Btu per hr

Steam consumption = $\frac{765000}{933}$ = 820 lb per hr, or $\frac{820}{205}$ = 4 lb steam per lb water

Temperature difference or drop through dryer = 180 — 154 = 26F

Assume 50% free air space in dryer or $\frac{8 \times 7 \times 25}{2}$ = 700 cu ft

Air change = $\frac{12,400 \text{ (av.cfm)}}{700}$ = 17.7 times per min

Percent recirculation = $\frac{410}{720}$ = 57%, so that percent exhaust = 43%

Check with

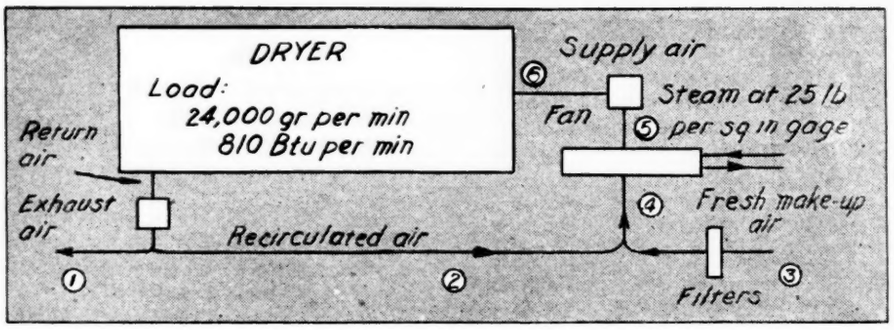


FIG. 8. AIR FLOW AND HEAT BALANCE CHART FOR CERAMIC POWDER DRYER—WINTER CYCLE

DATA	STATION NO. 1	2	3	4	5	6
Dry bulb temperature, F	154	154	0	130	195	180
Wet bulb temperature, F	99+	99+	0	91.7	101.5	100
Dewpoint temperature, F	87—	87—	0	81+	81+	81+
Percent relative humidity	16	16	100	24	5	7
Total heat, Btu per lb air	70.3	70.3	.83	58.0	74.1	71.4
Moisture content, grains per lb air	195.7	195.7	5.5	162.4	162.4	162.4
Specific volume, cu ft per lb air	16.45	16.45	11.59	15.5	18.4	17.9
Airflow, lb per min	126	594	126	720	720	720
Airflow, cfm	2080	9750	1455	11180	13200	12900
Moisture content, grains per cu ft	11.9	11.9	.475	10.5	8.8	9.1
Vapor pressure, in. mercury	1.28	1.28	.04	1.08	1.08	1.08

At 87F moisture is 195.7 gr. per lb
At 0F moisture is 5.5 gr. per lb less
Pick up per lb fresh air = 190.2 gr. per lb

$$\therefore \frac{24000}{190.2} = 126 \text{ lb fresh air per min}$$

Return air = 720—126 = 594 lb air per min
At station four: 126 × 5.5 = 695 gr per min

$$594 \times 195.7 = \frac{116{,}300}{116{,}995} \text{ gr. per min, in mixture}$$

$$\frac{116995}{720} = 162.4 \text{ gr. per lb air (check with summer cycle)}$$

$126 \times .83 = 105$ Btu

$$594 \times 70.3 = \frac{41{,}785}{41{,}890} \text{ Btu per min, in mixture}$$

$$\frac{41890}{720} = 58 \text{ Btu per lb, air}$$

Total heat demand = (74.1 — 58) 720 × 60 = 695,000 Btu per hr

$$\text{Steam consumption} = \frac{695{,}000}{933} = 745 \text{ lb per hr, or } \frac{745}{205} = 3.6 \text{ lb steam per lb water}$$

$$\text{Percent recirculation} = \frac{594}{720} = 82.5\%; \text{ percent exhaust} = 17.5\%$$

Other data as shown on Summer Cycle.

ciency, such a procedure seemed to be rational.

For the sake of brevity, subsequent computations will be omitted. The final data are presented on two air flow and heat balance charts, one for extreme summer (Fig. 7) and the other for extreme winter conditions (Fig. 8).

The analysis of heat losses is as follows: The initial and final powder temperatures were assumed to be 72F and 150F, respectively. The moisture evaporating temperature was taken as 100F. The heat transmission coefficient (K) for the dryer housing was taken as .4 Btu per hour per sq ft housing area per F mean temperature difference. The dryer was to be located on the ground floor, so that floor heat loss could be neglected. Assuming an average temperature in the dryer of 150F the *heating load* (not to be confused with the total heat demand) is:

Powder—895.5 lb per hr × (150F—72F) × 0.22 Btu per lb	15,400 Btu per hr
Moisture—210 lb per hr × (100F—72F)	5,900 Btu per hr
Housing—662 sq ft × .4 × (175F—72F)	27,200 Btu per hr
TOTAL	48,400 Btu per hr or 810 Btu per min

Examination of the chart will disclose the heat loss between the outlet of the heater and the inlet to the dryer. Certain allowance for this loss should always be made, or actually computed. In addition, depending on the rate of air circulation and the heat given up by air to offset heat transmission losses, and heating up of the material, the wet bulb temperature may drop through the dryer and a corresponding correction should be made.

The fan is shown on the outlet heater side, but for high temperature work it may be advantageous to locate it on the inlet heater side. The latter practice will result in power economy.

It would have been desirable or possible for the sake of heat economy to divide the dryer into two zones instead of one but, because of additional expenses, rather low initial moisture content of powder, absence of the danger of establishing too great temperature or moisture gradients in the material, and low absolute steam consumption, the idea of a multiple zone dryer was abandoned.

The overall heat utilization may seem poor, but the removal of bound moisture in the regain region requires considerably greater energy than the evaporation of unbound moisture. By the energy is meant not only the heat demand, but other sources such as extra power, water, and heat that may be required for production of dehumidified air, delivery of well water, and so on.

In the case of the winter cycle, an additional 5F drop was allowed between the heater and dryer, which would, from the standpoint of the total heat demand, compensate for the variations in room and powder temperature, and transmission losses previously mentioned. Paradoxically enough, but not unusual, the steam consumption is less in winter than in summer. This is just another good reason not to use winter conditions of make-up air as basis for drying computations.

In the system described, uniform drying conditions will be maintained throughout the year independently of vagaries of weather. However, it is quite possible to take advantage of dryer make-up air in winter and either speed up the process or operate at lower dry bulb temperatures. Such a practice requires utmost care, usually results in the extreme dissatisfaction when the following summer arrives, and is, therefore, not recommended.

In the preceding computations, a rather detailed analysis has been presented for the sake of clarity. However, the knack of doing the job and the acquistion of practical experi-

ence will substantially shorten the time consumed in figuring out an installation.

The value of experience or of previous records cannot be overemphasized; for example, there is no theory to give an answer as to just why the percent pick-up is 35% instead of, say, 50%. However, a thorough understanding of established pick-up or of regain data is imperative. In the foregoing case the drying temperature was reduced approximately 200F without any compromise with results.

The physical form of the drying system must embody the previously determined method of material handling, rates of air circulation, provisions for operating flexibility, safety, cleanliness, ease of maintenance, and means for insuring uniformity of results.

The design work can be divided into three parts, namely: air distribution means, apparatus design, and the material handling equipment.

Air Distribution. Circulation of large volumes of air does not necessarily imply high velocities. For instance, the longitudinal air flow in the above dryer housing, assumed for the sake of discussion to be empty) will cause air velocity in the vicinity of 220 feet per minute (12,400 cfm divided by the face area of 8 ft wide times 7 ft high), whereas the vertical flow will result in the velocity of only 62 ft per min (12,400 divided by the face area of 8 ft wide times 25 ft long). Furthermore, by using center supply or exhaust in the first case and by subdividing the vertical flow into several decks with individual supply and return air means, the actual velocities could be further decreased without reducing the rate of air circulation through the housing as a whole.

Consequently, each belt was provided with its own air supply and return system, and the requirements of not exceeding the maximum velocity were met. Air was supplied almost the full width and length of each pass.

To facilitate air distribution, the supply ducts were divided into several headers. The return air openings were provided at regular intervals so as not to exceed the permissible longitudinal air velocity parallel to the material bed. Because of these longitudinal components, the actual air flow in relation to the material was not at right angles, but somewhat inclined. The housing, besides accommodating the belts and ductwork, also incorporated two spaces, one on each belt side for servicing, and extending the full length of the dryer, features which made it possible further to reduce the longitudinal component.

Headers were of perforated type equipped with internal baffles. Both the static and the velocity principles were used to insure uniform air distribution over the entire outlet face area of each header. All adjacent layers of material across the belt will receive equal treatment by the air, provided air is evenly distributed across the belt, whereas the longitudinal distribution, because of the material travel, becomes of secondary significance.

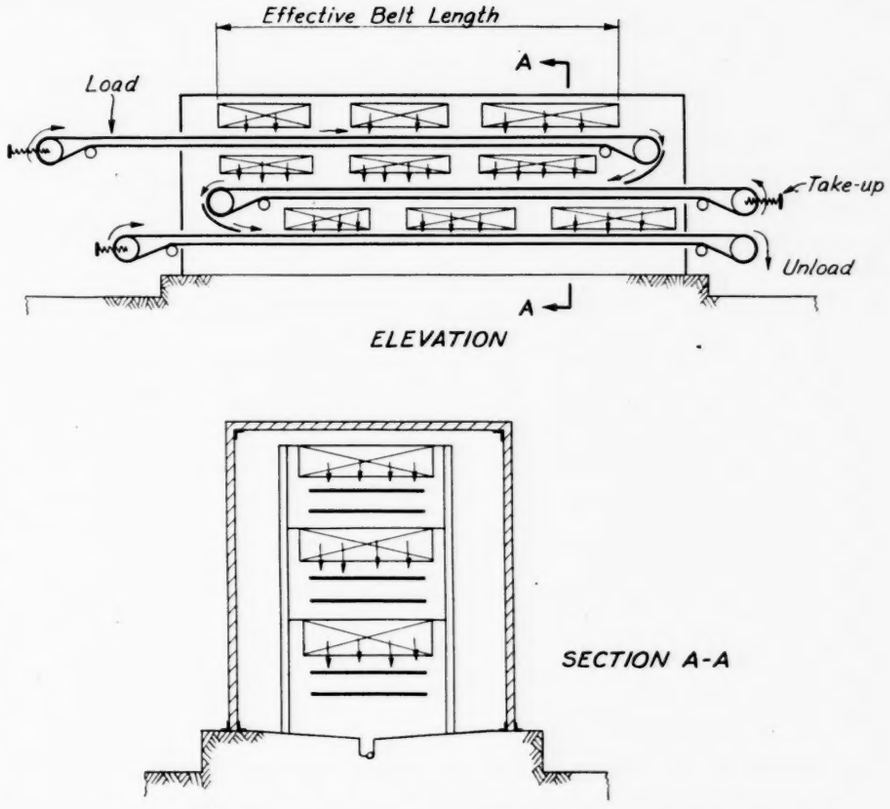


Fig. 9. Sketch, not to scale, showing dryer for ceramic powder.

Apparatus Design, for the sake of economy, should consist of the selection of various readily available equipment items. Fans, motors, heaters, controls, and other devices put together in proper relative position form the system, as in air conditioning practice.

While the duties of various items are clearly shown on the air flow and heat balance chart, use or desirability of additional equipment may have to be considered. For example, make-up or fresh air could be filtered, return and exhaust air could be passed first through a dust collector and then through a bag or fine type air filter; this would necessitate the use of an additional fan or fans. In the example cited, only make-up air filters and one return air fan were used.

Selection of air filters, air heaters and fans is a problem which need not be discussed here. It must be remembered, however, that temperature will influence the fan performance, that proper fan features must be added, and that performance corrections must be made in selection of fan and motor sizes.

Automatic controls are means which compensate for variations in the duty imposed on the dryer. These variations are caused by the changes in weather, when starting or finishing the run, due to the reasonable variations in the material conditions, or because of an entirely new product being handled by the dryer. Hence, the apparatus and controls must permit a latitude of conditions to insure operating flexibility. The range of controls is thus considerably greater than that encountered in the air conditioning practice.

Controls on the above jobs consisted of one recorder-controller with two (dry and wet) remote type bulbs. The dry bulb was located in a specially-constructed box with access door in the main return air duct, and was controlling the dry bulb temperature maintained in the dryer by modulating the diaphragm steam valve. The wet bulb was located adjacent to the dry bulb and was controlling the wet bulb temperature maintained in the dryer by simultaneous positioning of three sets of multiblade dampers located in the fresh, exhaust, and recirculated air ducts.

One safety dry bulb thermostat was located in the supply air duct. Its purpose was to limit the supply air temperature by throttling the steam admission to the heaters. The safety diaphragm steam valve was installed ahead of the normally operating steam valve. During the starting-up of the dryer, and should any

trouble develop with the normally operating controls, the supply air temperature may become sufficiently high adversely to affect the rubber belts. For this reason the maximum was set at 195F. All controls were of the full floating or modulating type, pneumatically actuated.

To prevent freezing of the heaters during shut-down period in winter time, the fresh make-up and, hence, the exhaust air dampers, were of the normally closed type, or were opened by the air pressure from the wet bulb thermostat.

Material Handling. Selection and design of material handling means dominated the solution of the entire problem described, the belt life having been the prime consideration. Without becoming too involved in chemistry, it will suffice to state that rubber failure is due to the vulcanization caused by the *continuous* exposure to temperature. The process of vulcanization stops upon cooling. The next cycle starts at the beginning and not as a continuation of the previous cycle. Full benefit from this phenomenon was derived by simply carrying the loading end pulley of each belt outside the dryer housing and allowing it to cool off, thus breaking up the vulcanization, and substantially prolonging the belt life. Excessive cooling, while advantageous for the rubber, will impede the drying process, especially in the final stages. The material will be giving up its heat to the belts, which is not desirable. All belts were made endless at the factory to further prolong their lives. Open end pulley arrangements also facilitated cleaning and inspection.

So as not to exceed allowable stresses caused by belt flexing, the minimum pulley diameter was determined to be 12 inches. All pulleys were crowned. Screw take-ups were used. All driven pulleys were connected together. Power was transmitted through a single variable speed unit. By equipping each belt with its own variable speed drive, and by making each belt an independently controlled drying zone, the maximum flexibility in the drying time and conditions, without sacrifice of production, could be achieved. This, of course, would be accomplished at the expense of varying the thicknesses of the material bed which, in the case of materials shrinking during the drying process, would be especially desirable.

The dryer housing was made of galvanized steel with 2 inches thickness of insulation to prevent condensation and to reduce heat loss. The housing was set on a concrete platform to facilitate unloading and washing.

Numerous secondary problems presented themselves, but their solution was a matter of common sense rather than calculations. For example, to keep down the dust formation at the point of transfer from one belt to another, an included shoe or hopper had to be used. The minimum angle of this shoe will vary not only with the nature of the material but also with its moisture content, and this had to be determined in the field.

There are numerous methods of uniformly loading wide belts (up to 8 ft width), and the loading of a belt 46 in. wide presented no difficulties.

STEAM LOSSES FROM PIPING – ½ TO 6 INCH PIPE

A	B	C	D	E	F	Pipe Size, Nominal Diameter, Inches										
Temp. Diff., F	Sat. Steam Temp., F (Col. A + 70F)	Abs. Steam Press. Corresponding to B	Latent Heat of Vapor., Btu per Lb	Heat Loss, Btu per Sq Ft per Hr	Heat Loss, Lb per Sq Ft per Hr (E÷D)	½	¾	1	1¼	1½	2	2½	3	4	5	6
						Outside Surface Area of Pipe per 100 Ft of Pipe, Sq Ft										
						21.99	27.49	34.43	43.46	49.74	62.18	75.27	91.63	117.81	145.64	173.44
						Heat Loss from Bare Piping in Pounds of Steam per 100 Ft of Pipe										
375	445	402	779.4	1441.70	1.8498	40.68	50.85	63.69	80.39	92.01	115.02	139.23	169.50	217.92	269.40	320.83
380	450	423	773.8	1476.16	1.9077	41.95	52.44	65.68	82.91	94.89	118.62	143.59	174.80	224.75	277.84	330.87
385	455	444	768.1	1510.62	1.9667	43.25	54.06	67.71	85.47	97.82	122.29	148.03	180.21	231.70	286.43	341.10
390	460	467	762.3	1545.08	2.0269	44.57	55.72	69.79	88.09	100.82	126.03	152.56	185.72	238.79	295.20	351.55
395	465	490	756.4	1579.54	2.0882	45.92	57.40	71.90	90.75	103.87	129.84	157.18	191.34	246.01	304.13	362.18
400	470	515	750.3	1614.00	2.1511	47.30	59.13	74.06	93.49	107.00	133.76	161.91	197.11	253.42	313.29	373.09
405	475	540	744.1	1657.66	2.2277	48.99	61.24	76.70	96.82	110.81	138.52	167.68	204.12	262.45	324.44	386.37
410	480	566	737.8	1701.32	2.3059	50.71	63.39	79.39	100.21	114.70	143.38	173.57	211.29	271.66	335.83	399.94
415	485	593	731.3	1744.98	2.3861	52.47	65.59	82.15	103.70	118.68	148.37	179.60	218.64	281.11	347.51	413.85
420	490	622	724.7	1788.64	2.4681	54.27	67.85	84.98	107.26	122.76	153.47	185.77	226.15	290.77	359.45	428.07
425	495	651	718.0	1832.30	2.5519	56.12	70.15	87.86	110.91	126.93	158.68	192.08	233.83	300.64	371.66	442.60
430	500	681	711.1	1875.96	2.6381	58.01	72.52	90.83	114.65	131.22	164.04	198.57	241.73	310.79	384.21	457.55
435	505	712	704.1	1919.62	2.7263	59.95	74.95	93.87	118.48	135.61	169.52	205.21	249.81	321.19	397.06	472.85
440	510	745	696.9	1963.28	2.8172	61.95	77.44	97.00	122.44	140.13	175.17	212.05	258.14	331.89	410.30	488.62
445	515	778	689.6	2006.94	2.9103	64.00	80.00	100.20	126.48	144.76	180.96	219.06	266.67	342.86	423.86	504.76
450	520	813	682.1	2050.60	3.0063	66.11	82.64	103.51	130.65	149.53	186.93	226.28	275.47	354.17	437.84	521.41
455	525	848	674.6	2104.54	3.1197	68.60	85.76	107.41	135.58	155.17	193.98	234.82	285.86	367.53	454.34	541.08
460	530	885	666.8	2158.48	3.2371	71.18	88.99	111.45	140.68	161.01	201.28	243.66	296.62	381.36	471.45	561.44
465	535	923	659.0	2212.42	3.3572	73.82	92.29	115.59	145.90	166.99	208.75	252.70	307.62	395.51	488.94	582.27
470	540	963	651.0	2266.36	3.4814	76.56	95.70	119.86	151.30	173.16	216.47	262.04	319.00	410.14	507.03	603.81
475	545	1003	642.8	2320.30	3.6097	79.38	99.23	124.28	156.88	179.55	224.45	271.70	330.76	425.26	525.72	626.07
480	550	1045	634.5	2374.24	3.7419	82.28	102.86	128.83	162.62	186.12	232.67	281.65	342.87	440.83	544.97	649.00
485	555	1089	626.1	2428.18	3.8783	85.28	106.61	133.53	168.55	192.91	241.15	291.92	355.37	456.90	564.84	672.65
490	560	1133	617.5	2482.12	4.0196	88.39	110.50	138.39	174.69	199.93	249.94	302.56	368.32	473.55	585.41	697.16
495	565	1180	608.7	2536.06	4.1664	91.62	114.53	143.45	181.07	207.24	259.07	313.60	381.77	490.84	606.79	722.62
500	570	1228	599.7	2590.00	4.3188	94.97	118.72	148.70	187.70	214.82	268.54	325.08	395.73	508.80	628.99	749.05

The accompanying table (a companion to Reference Data 285-286 covering 7 to 24 in. pipe) gives the heat loss from steam pipe (or flat surfaces) in terms of pounds of steam, for bars and insulated pipe, provided the following are known: (1) pipe size and length; (2) steam pressure; (3) steam quality (whether saturated or superheated—if the latter, degree of superheat); (4) temperature of air surrounding pipe; and (5) insulation efficiency factor, if loss when covered is desired. The following explains the use of the tables, which were computed by Charles A. Pohlig, Assistant to the Superintendent of Steam Distribution, Union Electric Co. of Missouri.

Example. One hundred feet of 1 in. bare piping is carrying steam at 90 lb pressure, absolute (dry saturated). The surrounding still air temperature is 70F. What are the losses per hour expressed in pounds?

Solution. Consult table, column C and proceed downward until 90 lb absolute pressure is reached, thence read across to the right to the 1 in. pipe size column and read 28.40 lb bare piping losses per 100 feet per hour.

If this pipe was insulated with 80% efficiency pipe covering the losses would be

$(1.00 - .80) \times 28.40 = 5.68$ lb per 100 ft per hr.

In case the steam is superheated, proceed as follows:

Example. If 100 feet of 2 in. bare piping is passing steam at 103 lb pressure (absolute) and 50F superheat and surrounding still air temperature is 70F and insulated pipe covering rated at 85% efficiency is used, what are the losses before and after the covering is applied?

Solution. In column C locate 103 lb pressure absolute and in column B find the corresponding steam temperature as 330F. With 50F superheat the steam temperature will be $330 + 50 = 380$F. Follow down column B to 380F and note that the corresponding absolute steam pressure is 196 lb. Continue to the right and under 2 in. diameter find the uncorrected bare piping losses as 76.34 lb per hour per 100 ft. In column D the latent heat of vaporization for 196 lb absolute pressure is 844.1 Btu per pound while for 103 lb absolute pressure the latent heat is 886.5 Btu per hour. The ratio is therefore $844.1 \div 886.5 = 0.9522$. The corrected bare piping loss is therefore $0.9522 \times 76.34 = 72.69$ lb per hour per 100 ft for the superheated line. The losses after covering with 85% efficiency insulation will be $(1.00 - 0.85) \times 72.69 = 10.90$ lb per hour.

If the surrounding air temperature is other than 70F it is possible to compensate for this in the same manner as is employed when solving the problem for superheat.

Column F of the table may be used to determine heat losses for flat or curved surfaces.

Proceed down column F if the desired absolute pressure does not appear in column C. Interpolation in the body of the table will yield reasonably accurate results.

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STEAM LOSSES FROM PIPING – ½ TO 6 INCH PIPE

A	B	C	D	E	F	Pipe Size, Nominal Diameter, Inches										
Temp. Diff., F	Sat. Steam Temp., F (Col. A + 70F)	Abs. Steam Press. Corresponding to B	Latent Heat of Vapor, Btu per Lb	Heat Loss, Btu per Sq Ft per Hr	Heat Loss, Lb per Sq Ft per Hr (E÷D)	½	¾	1	1¼	1½	2	2½	3	4	5	6
						Outside Surface Area of Pipe per 100 Ft of Pipe, Sq Ft										
						21.99	27.49	34.43	43.46	49.74	62.18	75.27	91.63	117.81	145.64	173.44
						Heat Loss from Bare Piping in Pounds of Steam per 100 Ft of Pipe										
50	120	1.692	1025.1	97.50	0.0951	2.09	2.61	3.27	4.13	4.73	5.91	7.16	8.71	11.20	13.85	16.49
55	125	1.941	1022.2	109.27	0.1069	2.35	2.94	3.68	4.65	5.32	6.65	8.05	9.80	12.59	15.57	18.54
60	130	2.221	1019.4	121.04	0.1187	2.61	3.26	4.09	5.16	5.90	7.38	8.93	10.88	13.98	17.29	20.59
65	135	2.536	1016.5	132.81	0.1307	2.87	3.59	4.50	5.68	6.50	8.13	9.84	11.98	15.40	19.04	22.67
70	140	2.887	1013.6	144.58	0.1426	3.14	3.92	4.91	6.20	7.09	8.87	10.73	13.07	16.80	20.77	24.73
75	145	3.280	1010.6	156.35	0.1547	3.40	4.25	5.33	6.72	7.69	9.62	11.64	14.18	18.23	22.53	26.83
80	150	3.716	1007.7	168.12	0.1668	3.67	4.59	5.74	7.25	8.30	10.37	12.56	15.28	19.65	24.29	28.93
85	155	4.201	1004.7	179.89	0.1790	3.94	4.92	6.16	7.78	8.90	11.13	13.47	16.40	21.09	26.07	31.05
90	160	4.739	1001.8	191.66	0.1913	4.21	5.26	6.59	8.31	9.52	11.90	14.40	17.53	22.54	27.86	33.18
95	165	5.334	998.8	203.43	0.2037	4.48	5.60	7.01	8.85	10.13	12.67	15.33	18.67	24.00	29.67	35.33
100	170	5.990	995.8	215.20	0.2161	4.75	5.94	7.44	9.39	10.75	13.44	16.27	19.80	25.46	31.47	37.48
105	175	6.716	992.8	229.68	0.2313	5.09	6.36	7.96	10.05	11.50	14.38	17.41	21.19	27.25	33.69	40.12
110	180	7.510	989.8	244.16	0.2467	5.42	6.78	8.49	10.72	12.27	15.34	18.57	22.61	29.06	35.93	42.79
115	185	8.382	986.8	258.64	0.2621	5.76	7.21	9.02	11.39	13.04	16.30	19.73	24.02	30.88	38.17	45.46
120	190	9.336	983.8	273.12	0.2776	6.10	7.63	9.56	12.06	13.81	17.26	20.89	25.44	32.70	40.43	48.15
125	195	10.385	980.8	287.60	0.2932	6.43	8.06	10.09	12.74	14.58	18.23	22.07	26.87	34.54	42.70	50.85
130	200	11.525	977.7	302.08	0.3090	6.79	8.49	10.64	13.43	15.37	19.21	23.26	28.31	36.40	45.00	53.59
135	205	12.772	974.6	316.56	0.3248	7 14	8.93	11.18	14.12	16.16	20.20	24.45	29.76	38.26	47.30	56.33
140	210	14.123	971.5	331.04	0.3408	7.49	9.37	11.73	14.81	16.95	21.19	25.65	31.23	40.15	49.63	59.11
145	215	16	968.3	345.52	0.3568	7.85	9.81	12.28	15.51	17.75	22.19	26.86	32.69	42.03	51.96	61.88
150	220	17	965.1	360.00	0.3730	8.20	10.25	12.84	16.21	18.55	23.19	28.08	34.18	43.94	54.32	64.69
155	225	19	961.7	377.30	0.3923	8.63	10.78	13.51	17.05	19.51	24.39	29.53	35.95	46.22	57.13	68.04
160	230	21	958.6	394.60	0.4116	9.05	11.31	14.17	17.89	20.47	25.59	30.98	37.71	48.49	59.95	71.39
165	235	23	955.0	411.90	0.4313	9.48	11.86	14.85	18.74	21.45	26.82	32.46	39.52	50.81	62.81	74.80
170	240	25	952.0	429.20	0.4508	9.91	12.39	15.52	19.59	22.42	28.03	33.93	41.31	53.11	65.65	78.19
175	245	27	949.0	446.50	0.4705	10.35	12.93	16.20	20.45	23.40	29.26	35.41	43.11	55.43	68.52	81.60
180	250	30	945.2	463.80	0.4907	10.79	13.49	16.89	21.33	24.41	30.51	36.93	44.96	57.81	71.47	85.11
185	255	33	941.2	481.10	0.5112	11.24	14.05	17.60	22.22	25.43	31.79	38.48	46.84	60.22	74.45	88.66
190	260	35	938.4	498.40	0.5311	11.68	14.60	18.29	23.08	26.42	33.02	39.98	48.66	62.57	77.35	92.11
195	265	39	934.4	515.70	0.5519	12.14	15.17	19.00	23.99	27.45	34.32	41.54	50.57	65.02	80.38	95.72
200	270	42	931.4	533.00	0.5723	12.58	15.73	19.70	24.87	28.47	35.59	43.08	52.44	67.42	83.35	99.26
205	275	45	928.2	553.48	0.5963	13.11	16.39	20.53	25.92	29.66	37.08	44.88	54.64	70.25	86.85	103.42
210	280	49	924.2	573.96	0.6210	13.66	17.07	21.38	26.99	30.89	38.61	46.74	56.90	73.16	90.44	107.71
215	285	53	920.9	594.44	0.6455	14.19	17.74	22.22	28.05	32.11	40.14	48.59	59.15	76.05	94.01	111.96
220	290	58	917.0	614.92	0.6706	14.75	18.43	23.09	29.14	33.36	41.70	50.48	61.45	79.00	97.67	116.31
225	295	62	913.4	635.40	0.6956	15.30	19.12	23.95	30.23	34.60	43.25	52.36	63.74	81.95	101.31	120.64
230	300	67	909.6	655.88	0.7211	15.86	19.82	24.83	31.34	35.87	44.84	54.28	66.07	84.95	105.02	125.07
235	305	72	906.0	676.36	0.7465	16.42	20.52	25.70	32.44	37.13	46.41	56.19	68.40	87.95	108.72	129.47
240	310	78	902.1	696.84	0.7725	16.99	21.24	26.60	33.57	38.42	48.03	58.15	70.78	91.01	112.51	133.98
245	315	84	898.3	717.32	0.7985	17.56	21.95	27.49	34.70	39.72	49.65	60.10	73.17	94.07	116.29	138.49
250	320	90	894.4	737.80	0.8249	18.14	22.68	28.40	35.85	41.03	51.29	62.09	75.59	97.18	120.14	143.07
255	325	96	890.6	761.82	0.8554	18.81	23.51	29.45	37.18	42.55	53.19	64.39	78.38	100.77	124.58	148.36
260	330	103	886.5	785.84	0.8865	19.49	24.37	30.52	38.53	44.09	55.12	66.73	81.23	104.44	129.11	153.75
265	335	110	882.7	809.86	0.9175	20.18	25.22	31.59	39.87	45.64	57.05	69.06	84.07	108.09	133.62	159.13
270	340	118	878.5	833.88	0.9492	20.87	26.09	32.68	41.25	47.21	59.02	71.45	86.98	111.83	138.24	164.63
275	345	126	874.4	857.90	0.9811	21.57	26.97	33.78	42.64	48.80	61.00	73.85	89.90	115.58	142.89	170.16
280	350	135	870.2	881.92	1.0135	22.29	27.86	34.89	44.04	50.41	63.02	76.29	92.87	119.40	147.61	175.78
285	355	144	865.8	905.94	1.0464	23.01	28.77	36.03	45.48	52.05	65.07	78.76	95.88	123.28	152.40	181.49
290	360	153	861.7	929.96	1.0792	23.73	29.67	37.16	46.90	53.68	67.10	81.23	98.89	127.14	157.17	187.18
295	365	163	857.4	953.98	1.1126	24.47	30.59	38.31	48.35	55.34	69.18	83.75	101.95	131.08	162.04	192.97
300	370	173	853.0	978.00	1.1465	25.21	31.52	39.47	49.83	57.03	71.29	86.30	105.05	135.07	166.98	198.85
305	375	184	848.6	1007.14	1.1868	26.10	32.63	40.86	51.58	59.03	73.80	89.33	108.75	139.82	172.85	205.84
310	380	196	844.1	1036.28	1.2277	27.00	33.75	42.27	53.36	61.07	76.34	92.41	112.49	144.64	178.80	212.93
315	385	208	839.5	1065.42	1.2691	27.91	34.89	43.70	55.16	63.13	78.91	95.53	116.29	149.51	184.83	220.11
320	390	220	834.9	1094.56	1.3110	28.83	36.04	45.14	56.98	65.21	81.52	98.68	120.13	154.45	190.93	227.38
325	395	233	830.3	1123.70	1.3534	29.76	37.20	46.60	58.82	67.32	84.15	101.87	124.01	159.44	197.11	234.73
330	400	248	825.5	1152.84	1.3965	30.71	38.39	48.08	60.69	69.46	86.83	105.11	127.96	164.52	203.39	242.21
335	405	262	820.6	1181.98	1.4404	31.67	39.60	49.59	62.60	71.65	89.56	108.42	131.98	169.69	209.78	249.82
340	410	277	815.8	1211.12	1.4846	32.65	40.81	51.11	64.52	73.84	92.31	111.75	136.03	174.90	216.22	257.49
345	415	292	810.8	1240.26	1.5297	33.64	42.05	52.67	66.48	76.09	95.12	115.14	140.17	180.21	222.79	265.31
350	420	309	805.8	1269.40	1.5753	34.64	43.30	54.24	68.46	78.36	97.95	118.57	144.34	185.59	229.43	273.22
355	425	326	800.7	1303.86	1.6284	35.81	44.76	56.07	70.77	81.00	101.25	122.57	149.21	191.84	237.16	282.43
360	430	344	795.5	1338.32	1.6824	37.00	46.25	57.93	73.12	83.68	104.61	126.63	154.16	198.20	245.02	291.80
365	435	362	790.2	1372.78	1.7373	38.20	47.76	59.82	75.50	86.41	108.03	130.77	159.19	204.67	253.02	301.32
370	440	382	784.9	1407.24	1.7929	39.43	49.29	61.73	77.92	89.18	111.48	134.95	164.28	211.22	261.12	310.96

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Experiences with air conditioning as related to

Maintenance of Dehumidifiers and Interchangers

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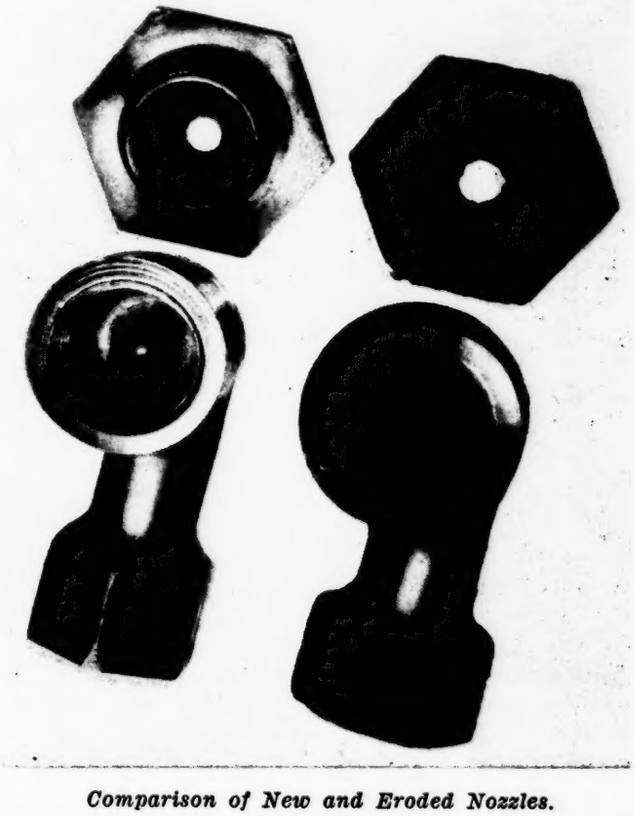
The accumulation of experiences of several companies in various parts of the country regarding dehumidifier maintenance and freeze-up of interchangers.

Dehumidifier Maintenance

THE average air washer dehumidifier is susceptible to small faults after a few years of operation, particularly if the dehumidifier is of the spray washer or wetted-coil type.

In the spray washer, the primary difficulty is with nozzles. Clogged nozzles can become a source of extremely large air by-pass due to the tendency of the nozzle stoppage to occur in dehumidifier section.



Comparison of New and Eroded Nozzles.

New nozzle body, left, shows center nipples about 3/8 in. high, acting as stream stabilizer while eroded nozzle, right, shows nipples completely eaten away. Comparison of nozzle caps above shows effect of erosion around the spray outlet.

Just as much difficulty can be encountered with nozzle erosion as might be expected from clogging of nozzles. In this case, the internal parts of the nozzle gradually wear away until the spray aperture is too large to create a fine spray through the dehumidifier chamber. The result is either a coarser spray or, in extreme cases, an unbroken stream of water, and the air no longer obtains its intimate contact with the water spray.

Either of the two conditions can also occur with the wetted-coil type of dehumidifier where a water spray covers the external surface of a coil through which the cooling medium flows. The greatest difficulty in the wetted-coil type of dehumidifier is not from the sprays, but is due primarily to contamination in the water. In general, water temperatures are sufficiently low so that no difficulties are encountered as a result of deposition of salt out of the water. Normal temperatures, however, are not low enough to prohibit the growth of some forms of algae. Algae grow around the fin surfaces of the coil and gradually multiply until they close off the air and water passages around the fin. One case was so severe that the growth blocked off the cooling coil in less than 2½ months of operation.

Obviously water treatment is required for the removal of particular fungus growth. In fact, it might be well to consider proper precautions in handling and treating water, even though the installation is in a locality where water conditions are believed good. In many cases $25 spent in water treatment will easily save $2,500 in maintenance and equipment repairs at a later date.

Freeze-Up of Interchangers

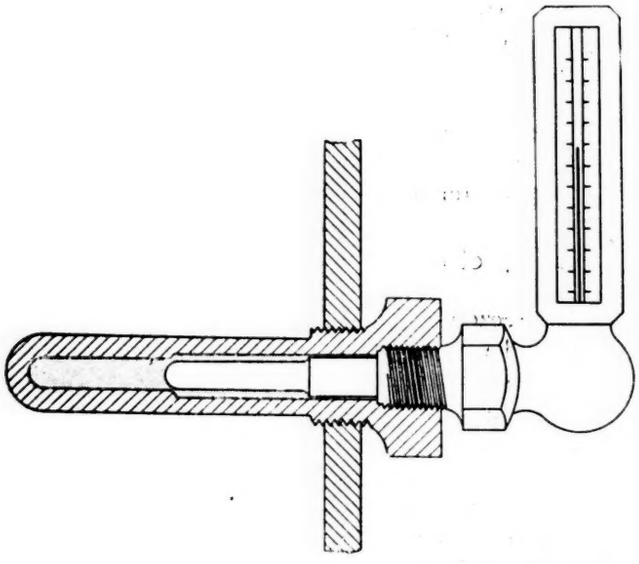
The freeze-up in a water cooler, which is usually associated with an evaporator or an interchanger, is always an expensive form of trouble. Most manufacturers of such equipment furnish low-limit thermostatic safety switches which will provide protection against such occurrences. However, the mere presence of a thermal safety switch is not a guarantee against freeze-up, for it is absolutely essential that these thermal switches be tested and recalibrated at least once a month.

In the last few years, several freeze-up cases have

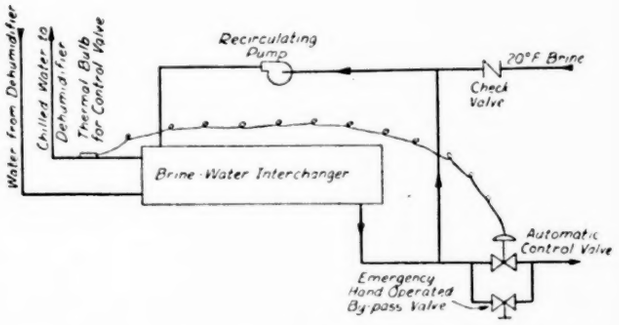
occurred where the freeze protection thermostats were not at fault. The first incident, and perhaps the most expensive, involved the freeze-up of a chilled brine to water interchanger designed to cool the water to 40F with the 20F brine. In order to prevent freeze-up, a centrifugal pump was installed to recirculate the brine in the interchanger. By means of bleeding small quantities of the low temperature brine into the recirculation brine circuit it was possible to maintain brine temperatures above 32F within the interchanger. The control of the brine supply into the recirculation system was maintained by a thermostat placed in the leaving-water circuit. Adjacent to the leaving-water thermostat was an insertion type of thermometer designed with a separate well.

For some reason, this thermometer was removed from its well and the operating engineer borrowed a thermometer from another part of the circuit. When this second thermometer was installed, he discovered that the chilled water temperature was apparently running 20 degrees high. Because he was unable to lower this temperature very much by means of the automatic control, he opened up a hand by-pass in the brine circuit, which permitted straight-through flow of the low temperature brine. By the time he was able to bring the temperature of the leaving chilled water down to the design conditions, the water was frozen almost solid in the interchanger and approximately 50% of the tubes burst.

Blame for the failure was immediately placed on the contractor. He had a rather baffling problem in determining the cause of the trouble. The problem was even more acute for the second insertion thermometer had been removed from the well. In reviewing the case with the operating engineer, the substitute thermometer was identified and immediately the cause of the trouble was determined. The thermal well and thermal bulb of the original thermometer was of a 4½ in. length in order to accommodate approximately 2 in. of insulation around the leaving chilled water piping. The second thermometer had a thermal bulb of only 2½ in. length. The dead air space between the thermal bulb and the thermometer well was sufficient to give a very serious error in the reading of the thermometer; in fact, on a retest, the error was found to be approximately 22F. When the operating engineer thought he was getting 50F leaving chilled water, the temperature of the leaving chilled water was actually around 28F.



Showing the result of placing short stem thermometer in well for long stem bulb. Dead air space seriously alters the temperature reading.



Schematic Arrangement of Brine and Water Piping Using 20F Brine

Recirculating pump in brine pumping system maintains the brine in interchanger about 32F to prevent freezing of water. As effluent water temperature rises, automatic control valve opens to release part of the warm brine from the piping circuit into the return line. The quantity of warm brine released is made up with 20F brine. Check valve prevents warm brine from backing into the low temperature brine supply line.

Another Freeze-Up Experience

The second freeze-up experience involved an evaporator on which the low-limit thermal switch had actually operated but the engineer in charge did not believe that the opening of this switch was due to low temperature conditions. Due to this belief, he proceeded to block the switch in a closed position and in this manner operated the system for approximately one-half hour. At the end of the half-hour operation, 98% of the tubes in the cooler had frozen solid.

During this time the operator had busied himself with checking all of the various motors and thermal switches on the job, thinking they had been responsible for the operation of the relay switch. The operating engineer, in his excitement and anxiety to get the machine back on the line, had failed to recognize the tripped relay as the thermal limit switch relay and thus, more or less unknowingly, caused the freeze-up. A series of relays serving various functions had been mounted on a common control panel. The operator failed to recognize the low-limit thermal relay as such, possibly because of its location in the center of the relay group.

Since that unfortunate occurrence, the thermal safety relays have been rewired to include both a warning light and a siren to provide both a visible

and an audible warning to the operating personnel.

A third freeze-up condition which occurred under rather extenuating circumstances may be placed under the heading "never-to-be-repeated experiences." Refrigeration equipment was installed on a job where the completion time was an important factor. Time finally assumed such serious proportions that it was necessary to install the refrigeration apparatus outside of an existing building, with the building extension to be constructed during and after the installation of the refrigeration equipment. Unfortunately, the building material situation was such that it was impossible to complete this building before the end of a winter.

The refrigeration apparatus was so designed that the cold weather could not impair its efficiency due to exposure. During the winter, the piping contractor completed all of the various interconnecting brine and waterlines. Anxious to complete the job as soon as possible, these contractors proceeded to give the entire system a hydrostatic test. This test proved successful and the contractors left the job with a feeling of satisfaction, but without realizing that they had not drained the water out of all these lines.

It took approximately one month for the low outside air temperatures to burst most of the large water mains, as well as the water boxes and heads on the interchanger. Here indeed is a case of carelessness where a low-limit temperature safety switch would have been of no use.

Summary

We have reviewed a group of difficulties which can be charged to: first, the designer; second, the construction man; and third, the owner and operator. The responsibility for these difficulties is not always well defined, for in many cases where the evidence is against the owner or operator of the equipment, there is a moral obligation that rests with the contractor or engineer. Indeed it is the recognition of "moral obligations" that has established the reputations of many companies.

We again wish to repeat that the motive in writing this article and others of this group* has been the hope of trading experiences with other people where the gain will be of mutual benefit to all concerned. These examples are not the experiences of any one company nor of any single individual, but instead represent an accumulation of troubles related by many people over the United States. For that reason the experiences should be of more value.

*Other articles by Mr. Schulz appeared in the August, September, October and November, 1944, issues.

Hog-House Heating and Ventilating

For fattening hogs the temperatures in the house should not drop below freezing at any time and a minimum of 40F is desirable, according to Hog-Housing Requirements, Circular No. 701 of the U. S. Department of Agriculture. The pamphlet, prepared by T. A. Miller, Wallace Ashby, and J. H. Zeller, goes on to state that in the farrowing house it is well to have the temperature in the range of 50 to 60F, since little pigs chill at lower temperatures. As it is not practicable without supplemental heat to keep the farrowing-house temperature above 50F in the coldest weather, in the colder areas farmers usually arrange for sows to farrow from the middle of March through April or May, and raise only one litter a year. Warmer houses would permit farrowing the first of March or the middle of February, with a second litter later in the year, as is the practice in the main hog-producing areas.

Use of brooders is very helpful in reducing the chilling of small pigs, and the popularity of this device is increasing, the Circular states. Pig brooders are on the market, and plans for home-made brooders are available from several of the State agricultural colleges and from the Rural Electrification Administration. In northern areas it is good practice to provide a chimney, so that in very cold weather a jacketed stove may be set in the alley or in a vacant pen. A thermometer should be kept in one of the colders parts of the house.

The capacity of the ventilation system should be based on the number of hogs that will be fattened in the house. Electric fans or gravity systems of ventilation may be used. A fattening hog weighing 200 to 400 pounds may breathe out 4 to 6 pounds of moisture daily; also, some moisture is evaporated from wet floors, troughs, and other surfaces. Under most conditions in the northern hog-producing areas a ventilation rate of 1,080 cubic feet of air per hour per 300-pound hog will be sufficient to remove this moisture and will require an outlet-flue area of about 20 square inches per hog for gravity ventilation.

Outlets three to five pens apart, with inlets at every other pen, on each side of a two-row house may be expected to give good results. Total inlet area may be somewhat less than total outlet area. Dampers should be provided on both outlets and inlets to control the volume of air circulated according to the conditions of the weather and the occupancy of the house. Inlets should be above the level of the pen partitions and have deflectors to diffuse cold air. Outlet ducts should be insulated their entire length, inlet ducts on the warm side. Flues that extend near the floor are in the way. Door and window openings will usually provide satisfactory ventilation in areas where the average annual minimum temperature does not fall lower and windows provide satisfactory ventilation in areas of somewhat lower minimum temperature.

WASHINGTON NEWS

Unit Heater Restrictions Eased; A. C. Situation Still Tight; Valve Industry Praised.

Summarized by LORING F. OVERMAN

"For the want of a nail, the shoe was lost . . . . ".

For the moment, a reference to this well-known quotation seems to sum up the situation in Washington as it affects the return to civilian production. Instead of a single nail, however, there appears to be one or more missing nails in just about every element comprising the picture.

For want of a major port the expected victory in Europe has been delayed.

For want of this victory, the manpower shortage in this country continues.

For want of specialized manpower —foundry workers, heavy tire makers, radar technicians and so on—reserve military stocks are consumed and must be replaced. This need for replacement, in turn, ties up the "nails" —the critical units without which complete civilian products cannot be produced.

It is in this puzzle of missing pieces that War Production Board post-war planners find themselves as they discuss plans for partial reconversion now, and as they prepare for the VE-Day conversion that must still be accomplished while licking a Far East enemy who has been underestimated from the start.

Piecemeal Planning

About the best that can be done under such circumstances by W.P.B. is to peck away at the things that can be changed as of now, with the hope that such changes may be helpful in easing some of the headaches when Germany gives up and the expected 40%-or-more cutbacks release an avalanche of the nails now missing. And that is exactly what W.P.B. is doing, along heating and ventilating lines as well as the thousand and one other phases of the wartime production schedule.

Unit Heaters Freed

In line with its policy of removing restrictions within an industry as soon as conditions permit, WPB announced on November 17 the revocation of Schedule 1 of Order L-107 (Extended Surface Heating Equipment). The Schedule had limited the types of equipment permitted and had required that the permitted types be in accordance with a long list of simplification rulings. Manufacturers are now on their own as far as types, styles and sizes are concerned.

Order L-107 itself, which requires a rating of AA-5 or better and a specific delivery date before delivery can be made, still remains in effect. The restrictions were originally enacted July 28, 1943, to assist the industry in meeting the greatly increased demand for such equipment from military and new war plants. Released by the revoked schedule are unit heaters, unit ventilators, convectors, blast heating coils and special heating coils for space heating or for industrial heating or drying.

Some Copper Released

Another nick at the restrictions problem was taken with the revocation of Schedule VIII of Order L-42 (Plumbing and Heating Simplification). Revoking of this schedule means that copper may be used in bodies of low pressure thermostatic radiator and drip traps, combination float and thermostatic traps, and boiler return traps. Previously only cast iron could be used.

More recently, on November 14, Copper Order M-9-c and M-9-c-4 were amended and a supplementary fourth-quarter allotment was granted to permit the use of 16,030,000 additional pounds of copper-base alloy in making a number of designated products. Included are a wide line of plumbing and heating components such as strainers, faucets, shower arms and tank floats.

The War Production Board anticipates a considerable saving of labor will be noted by permitting manufacturers to use the materials that their plants were originally designed to process. A saving of both manpower and materials is also expected to follow a reduction in the need for replacement of parts made from unsatisfactory substitutes.

Substitution of other materials for copper and copper base alloys was made necessary by the tremendous war demands for copper, but their use on machines made to handle brass and copper brought a costly number of rejects. Production and requirements are now more nearly in balance so that the WPB Requirements Committee found it possible to grant the Office of Civilian Requirements, Office of War Utilities, and other requests for copper to be used in a carefully selected list of essential products.

The Plumbing and Heating Division of WPB has been named to coordinate the use of copper alloys in the production of float rods, flush ells and valves for low tanks, sink, tub and lavatory plugs and strainers, oven thermostats, tubular goods, tank floats, single and combination faucets, closet and urinal spuds, shower valves and heads, flushometers, shower and urinal strainers, fixture stops, thermostatic traps, tri-cocks for low pressure boilers, cleanout plugs and shower arms.

The Office of War Utilities will be in charge of underground water and gas connections.

Slowdown Ordered

Despite its efforts to simplify manufacturing methods by releasing some supplies of standard materials, the WPB has been forced to suspend action, until further notice, on all applications by dealers for refrigeration and air conditioning equipment, including self-contained package units. These applications are made on WPB Forms 541 and 547. The denials will not affect applications for repair components, including compressor bodies and low-sides.

The action was taken on November 18 because applications for equipment submitted by dealers represent a manufacturers' backlog of orders covering periods of from four months to a year in the case of compressors, all on AA-1 rating. Dealers must now depend upon extending customers' ratings to replace inventories. WPB Form 541 and 547 had previously offered dealers a means of securing, by appeal, priorities assistance higher than that provided by extending customer ratings.

The slow-down order was the subject of lively discussion at the Chicago meeting of the National Refrigeration Supply Jobbers' Association on November 17. Purposes of the order were explained by Frank P. Millham, Assistant Chief, General Industrial Equipment Division, War Production Board.

The subject was also docketed as one of the chief subjects for discus-

sion at the December 6 meeting of the General Refrigeration and Air Conditioning Industry Advisory Committee at Washington. In preparation for the meeting, staff members of the Refrigeration and Air Conditioning Branch of WPB were studying the problem with a view to amending Order L-38 (General Refrigeration and Air Conditioning), to permit dealers and distributors to obtain a limited quantity of equipment for inventory.

"Freon" Outlook Brighter

The bottleneck that has been holding up the "Freon" production program is believed to have been solved by WPB's recent authorization for the construction of additional facilities for the production of anhydrous hydrofluoric acid. Erection of one new plant at Baton Rouge, La., to cost $700,000, and expansion of a plant at Houston, Texas, at a cost of $485,000 have been authorized. The seasonal drop in demand, plus the production of additional hydrofluoric acid—a component of "Freon"—is now expected by WPB to result in an all-over solution of the shortage by March, 1945.

It is expected that by the first of the year it may be possible to withdraw provisions forcing mandatory conversion to other types of refrigerant by specified users, and that in March the available F-12 supply will permit its use for comfort air conditioning and other purposes now prohibited.

Valves Get Back-Pat

Manufacturers of valves were given a hearty pat on the back in a WPB statement issued late in November, classifying the valve situation as "One of the Production Miracles of the War!" The exclamation point is also quoted directly from the WPB release, indicating that they really meant it. According to statistics released by the Valve and Fittings Section, Shipbuilding Division, output of valve manufacturers shows the following increases from 1940 through 1943:

Steel turbine valves, almost five times the tonnage produced in 1940; all other steel valves, more than five times; compressed gas cylinder valves, almost four times; brass and bronze valves, more than two times; iron body valves, almost two times; steel pipe fittings, almost three times.

WPB officials also called attention to the industry's efforts to reduce the backlog of orders. In 1943, these backlogs ran from six to nine months' full production at current production rates for steel valves. As of July 1, 1944, this backlog was cut down to four months production. The backlog in bronze and brass valves in 1943 and thus far in 1944 remained about the same—approximately five months' production.

Almost half of the entire output of the industry for last year and the first eight months of 1944 has been absorbed in ship construction. Enormous quantities of valves and pipe fittings have been used in the construction of synthetic rubber and high octane gasoline plants, pipe lines and Army projects. Lend-lease takes a substantial percentage, with public utilities also out in front. Essential civilian requirements—homes, apartments, offices, stores, hospitals, etc.—represent less than two percent, WPB reported.

Valve Peak Passed

"The general peak in demand for valves and fittings has passed, according to all present indications, although shortages of certain kinds of valves and fittings may appear from time to time," a Shipbuilding Division official said. "It is not possible, as long as material and manpower shortages exist, to meet promptly every demand for more than 100,000 different items produced by the industry, but essential and critical requirements are being met while the backlog of war orders is being reduced.

"It is expected that large surpluses of steel and brass valves will be reported by procurement agencies as a result of changes in war programs, cutbacks, over-ordering, etc., when inventories are compiled. The productive capacity of the industry is now adequate to take care of all essential needs for the duration."

Even before Pearl Harbor, the valve and pipe fittings industries were called upon for increased production, but they were handicapped by the lack of machine tools, foundry facilities and manpower, WPB said. Requirements of valves for warships, Maritime Commission vessels, public utilities, pipelines, etc., multiplied so rapidly that the industry early appealed for assistance to the Office of Production Management, WPB's predecessor.

Accordingly, the Steel Valve Industry Advisory Committee was formed, the first such industry advisory group to be legally authorized within OPM. At its initial meeting on August 4, 1941, it learned early estimates of what the military needs would be for valves and fittings. When Pearl Harbor was attacked in December of that year, requirements for steel valves skyrocketed. The Navy's overall requirements for 1942 jumped 103% over estimates made at the August 1941 meeting, and for 1943, they soared 1,000%.

The industry, after it was first apprised of the military requirements for steel valves in the fall of 1941, reported that it did not have the foundry facilities and enough machine tools to fill Army, Navy and Maritime Commission orders. The industry reported that its annual production would have to be increased by 14,600 tons to meet a production requirement of some 38,000 tons. The average annual shipment for three years ending with 1940 was 15,000 tons.

Government agencies approved the immediate expansion of the industry in 1942. Up to the present time, the valve and fittings industries have expanded plants and facilities to the extent of approximately $38,404,000. Of this amount, $19,948,000, or 52%, was financed by the Government, and $18,456,000 or 48%, was privately financed by the manufacturers.

The War Production Board, as OPM's successor, extended a helping hand to the industries by imposing three limitations orders—L-288, covering grey cast iron, malleable iron and brass or bronze pipe fittings; L-252, covering valves and valve parts, and L-278, covering steel pipe fittings. WPB took these steps to hasten increased production by the simplification and standardization of specifications and the substitution of free materials for those critically scarce.

Service Ceilings

Provisions of the regulation establishing specific maximum hourly rates for oil burner maintenance and repair services have been broadened to include similar services for coal stokers with a capacity under 1200 pounds of coal per hour, the Office of Price Administration announced November 16.

The hourly rates for stoker services (effective November 25, 1944), the same as those previously applying only to oil burner services, are:

The rates are inclusive of transportation, time spent in going to and from the job, and all other charges. The hourly prices do not apply to suppliers of stoker maintenance and repair services who have established prices under Revised Maximum Price Regulation No. 165 at prices higher than the specific hourly rates, provided these suppliers have complied with the filing requirements of MPR 165.

	First Hour	Second and Succeeding Hours
In cities of 500,000 population or more	$2.50	$1.75
In cities of 100,000 to 500,000 population	2.00	1.50
In cities less than 100,000 population	1.50	1.25

Graphical Determination of Heat Transfer Film Coefficient for Water

B. F. RABER* and F. W. HUTCHINSON**

Problems of heat transfer from or to fluids flowing in pipes are frequently difficult to solve because of the complexity of dimensionless formulas for determining the film coefficient for the fluid under consideration. In this article, the authors present two charts for easy determination of the film coefficient for water—one for heat transfer from, the other to, water in the pipe. Similar charts for other fluids will appear in subsequent issues. Their use will save considerable (and in many cases fruitless) search through handbooks.

IN recent years great advances have been made in the correlation of experimental data on heat transfer film coefficients. The empirical equations which had been used in evalution of such coefficients have been placed on a rational basis and single equations have been established from which numerical values of film coefficients can be determined for anyone of large families of fluids. The result has been a marked systemization of heat transfer procedures and a corresponding reduction in the mass of references, empirical equations, and correction factors which had formerly been necessary.

The over-all progress in the field of heat transfer has not always been reflected in simplified or in time-saving methods suitable for direct use by the practicing engineer. The over-all correlations have provided useful tools for the chemist who wishes one day to calculate the film coefficient of heptane and the next day of ethyl iodide, or chlorobenzine, or pentane, but no equivalent advantage has accrued to the refrigerating engineer who works with a given refrigerant or to the heating contractor whose interest in film coefficients may be limited to water or to steam. A generalized, dimensionless, exponential equation may represent a tremendous forward step to the scientists who would otherwise have to search in voluminous references and go to a multitude of sources for equivalent data, but the same equation can readily become a time-consuming and troublesome burden to the specialized engineer whose interest in heat transfer is limited to an individual fluid. On the other hand, the rational equations provide information concerning the variation as a function of temperature, diameter, and velocity of the film coefficient for any particular fluid; data which are not readily available — and sometimes unobtainable — from the older non-dimensionless, empirical equations.

Thus, when used for water (or ammonia, or dichlorodifluoromethane, or any other commonly used working substance) the generalized film coefficient equations are a mixed blessing; their use presupposes some facility in manipulating logarithms and requires more time than does reference to the older tabular sources or simple empirical equations, yet they provide a flexibility and a generality which are frequently advantageous and sometimes invaluable. To assist in bridging this gap between an accurate rational solution and a convenient empirical one, a series of full-page plates are being prepared, two for each of the working fluids used by, or of special interest to, the heating, air conditioning, or refrigerating engineer. Each such plate will afford a direct graphical means of readily evaluating the film coefficient; one is for flow inside, the other outside and normal to a pipe, and relating to the particular fluid for which it is constructed. The graphs will provide accuracy equal to that of the rational equation with what is hoped will be less effort than would be required with the empirical equations or by reference to tabular data. All graphs of the series will be constructed in a standard form so that once familiarity has been attained with the method of use the procedure will be the same regardless of which particular graph is used.

The first plates of the series—for water—are presented as part of this introductory article. If interest is sufficient to justify proceeding with the series, subsequent plates will be made available for each of the commonly used liquid refrigerants, for steam, and for certain of the vapors and gases which are of greatest interest in the fields of heating, air conditioning, and refrigeration. Comments and suggestions of readers are invited as to additions which they may care to see added to the series or of the fluids for which they are most desirous of having similar graphical solutions made available.

Attention is particularly directed to the fact that neither the graphs or water nor any of those which are to follow present new data or values which cannot be obtained from existing equations. The purpose of the graphical solution is not to provide original data, but to place existing rational theory in a form which will permit the engineer to secure an accurate solution in the shortest possible time and with the smallest amount of effort.

Theory of Flow Inside Pipe

Regardless of the fluid considered, all graphs of the series give the film coefficient of heat transfer for a liquid or a gas, heating or cooling, flowing tur-

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bulently *inside* of a pipe, as calculated from the fundamental equation developed by Nusselt in 1909,

$$\frac{hD}{k} = a\left(\frac{DG}{\mu}\right)^{n}\left(\frac{c_p\mu}{k}\right)^{m} \quad \ldots\ldots (1)$$

In the equation,

- h = film coefficient of heat transfer, Btu per hour per square foot per degree F difference between the average fluid temperature and the surface temperature.
- D = inside diameter of the pipe, feet.
- k = thermal conductivity of the fluid, Btu per hr per sq ft per F per ft.
- G = mass velocity, pounds per hour per square foot of pipe cross-section.
- μ = absolute viscosity, pounds per hour per foot.
- c_p = specific heat at constant pressure, Btu per pound per F.
- a, n, m = experimental constants.

The dimensionless groups of equation 1 are frequently referred to by name,

$\frac{hD}{k}$ = Nusselt's number.

$\frac{DG}{\mu}$ = Reynolds number.

$\frac{c_p}{k}$ = Prandt's number.

The three experimental constants which appear in equation 1 have been assigned various values by different experimenters, but the most widely accepted general values are doubtless those which were recommended by McAdams in the first edition of "Heat Transmission" (published by McGraw-Hill, 1933); these are:

$$\frac{hD}{k} = 0.0225\left(\frac{DG}{\mu}\right)^{0.8}\left(\frac{c_p\mu}{k}\right)^{0.4} \quad \ldots\ldots (2)$$

For cooling,

$$\frac{hD}{k} = 0.0225\left(\frac{DG}{\mu}\right)^{0.8}\left(\frac{c_p\mu}{k}\right)^{0.3} \quad \ldots\ldots (3)$$

Both of the above equations are for turbulent flow and should not be used when the Reynolds number is smaller than 10,000.

Regrouping terms and solving for h, equations 2 and 3 become,

$h = .0225\ (V^{.8})\ (D^{-.2})\ (\rho^{.8}\, k^{.6}\, c_p^{.4}\, \mu^{-.4})$ (fluid heating) (4)

$h = .0225\ (V^{.8})\ (D^{-.2})\ (\rho^{.8}\, k^{.7}\, c_p^{.3}\, \mu^{-.5})$ (fluid cooling) (5)

ρ = fluid density, pounds per cubic foot.

All four of the physical properties which appear in the last term of the above two equations vary only with the temperature of the fluid; for a given fluid temperature the last term therefore has a fixed value. Thus, the equations permit evalution of the film coefficient as a function of the three variables; fluid velocity, inside diameter of the pipe, and average fluid temperature. Noting that variation between the values of the film coefficient for heating and cooling occur only in the temperature term, a single graphical solution valid for both heating and cooling can be used provided the temperature factor is separately accounted for. The above equations are used as a basis for constructing all the graphical solutions for heating or cooling of liquids, vapors, or gases inside a pipe; graphs for evaporating liquids or for condensing vapors—as will be shown in a later article—are obtained differently.

Graph for Water Inside a Pipe

The accompanying full page graphical solutions for water are typical of all graphs in the series. Entering at the known fluid velocity in feet per second, rise to intersect the horizontal line corresponding to the actual *inside* diameter; then move upward to the left (see dashed line on figure) along a direction line to intersection with the horizontal scale; rise to the proper horizontal temperature line (solid for fluid heating-scale at right of chart; dashed for fluid cooling-scale at left of chart) then move downward to the right to read the answer on the horizontal scale.

Example: Water at 50F is being heated in a pipe having inside diameter of 0.5 in. The velocity is 7 feet per second. Determine the film coefficient.

Entering at the bottom of Fig. 1 for 7 feet per second (see the dashed line) rise to the .5 in. horizontal, follow a direction line to the scale, rise to the solid horizontal marked 50F and return along a direction line to read the answer as 1,040 Btu per hr per sq ft per F.

Example: If the water in the above case were cooling instead of heating the method of solution would differ only in that the dashed 50F horizontal would be used (see example on graph) and the corresponding film coefficient would then be 860 Btu per hr per sq ft per F.

Theory: Flow Outside and Normal to Pipe

For a liquid flowing outside of and normal to a single pipe McAdams suggests the equation,

$$\frac{hD}{k} = .86\left(\frac{DV\rho}{\mu}\right)^{.43}\left(\frac{C_p\mu}{k}\right)^{.3} \quad \ldots\ldots (6)$$

provided the Reynolds number, $\left(\frac{DV\rho}{\mu}\right)$, has a value less than 200 and greater than 0.1. When Reynolds number is between 200 and 1000 (the range of greatest practical importance for liquids) McAdams recommends the equation,

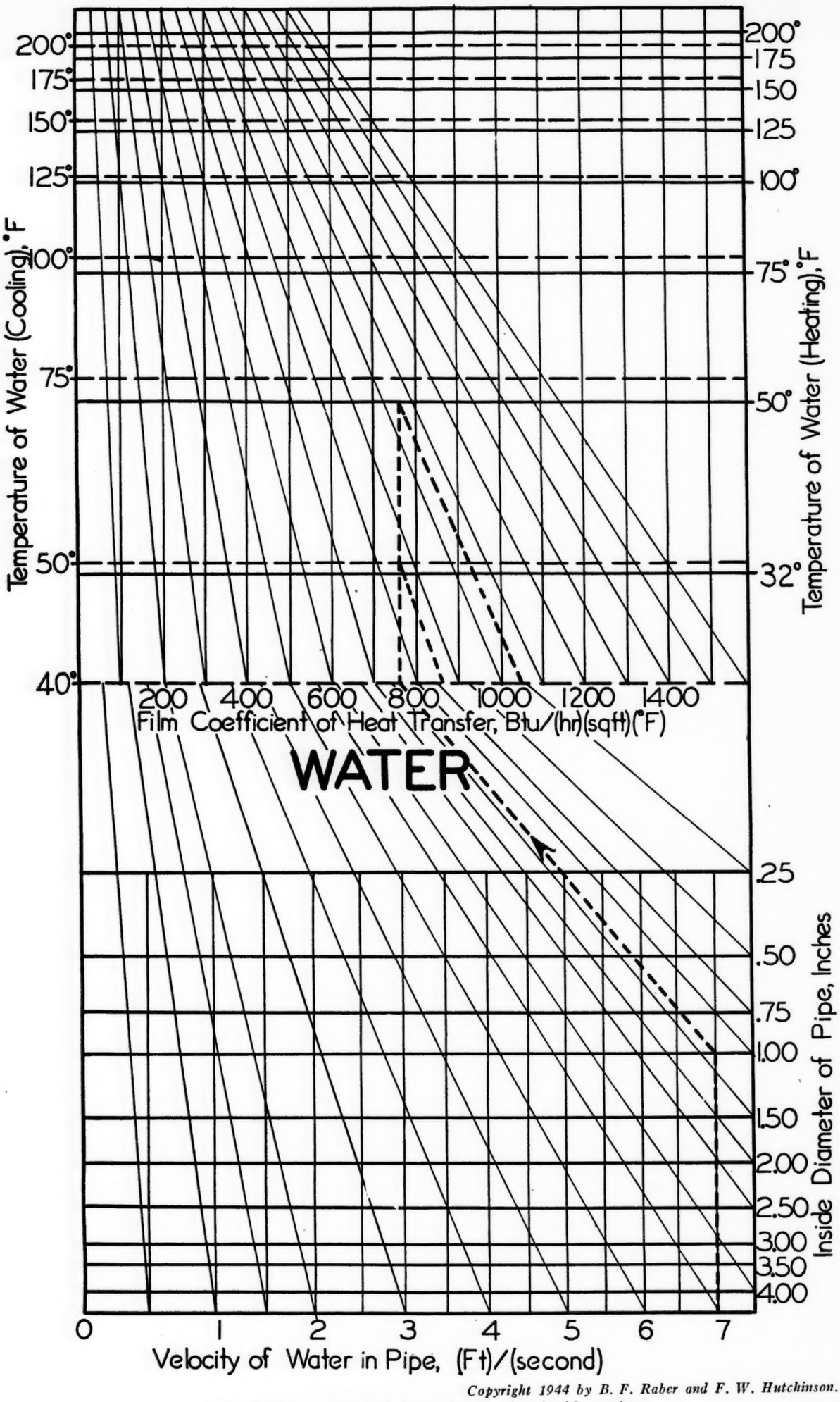

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Fig. 1. Film coefficient for water flowing inside a pipe.

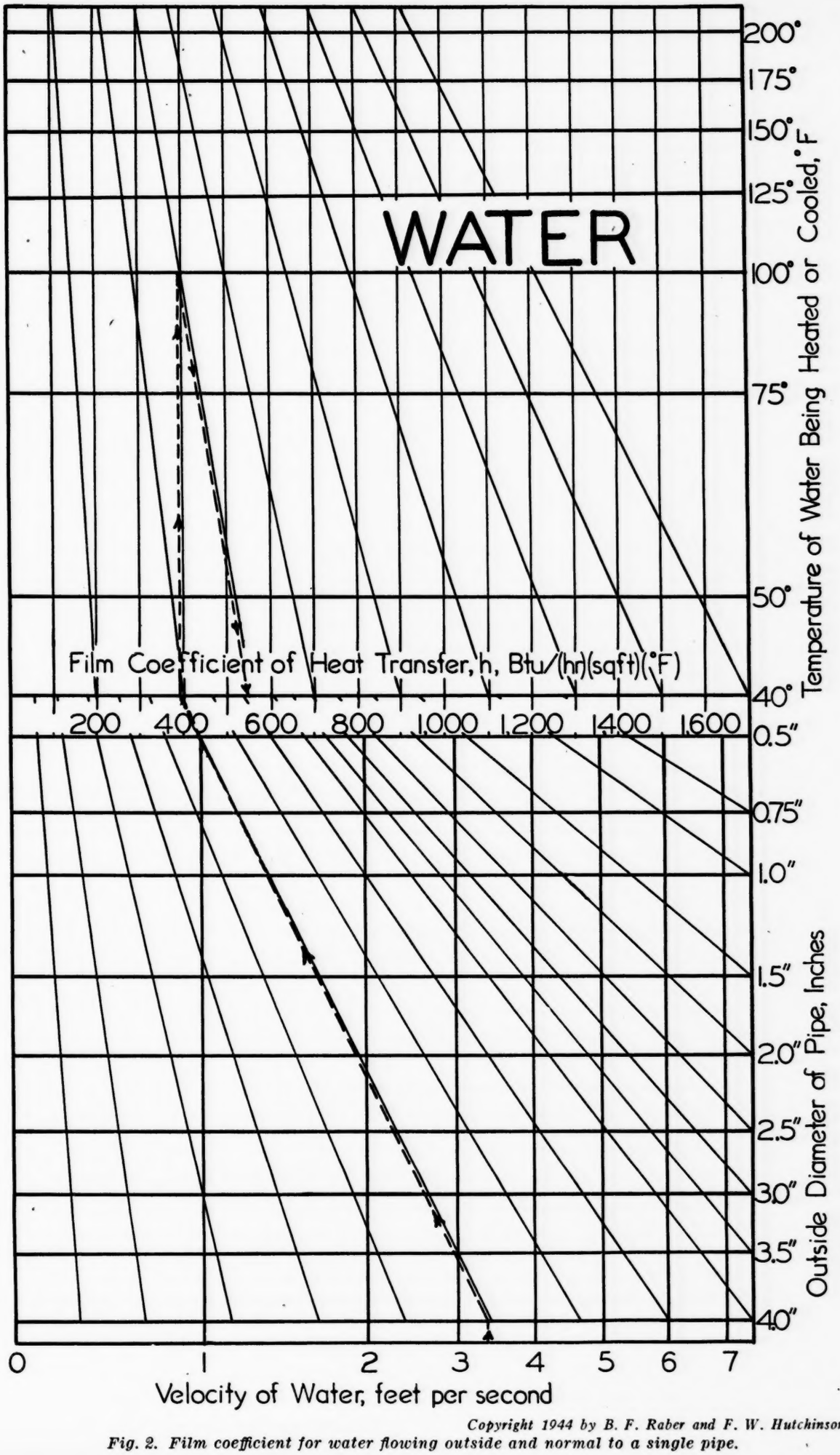

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Fig. 2. Film coefficient for water flowing outside and normal to a single pipe.

$$\frac{hD}{k} = 0.35 + 0.47 \left(\frac{DV\rho}{\mu}\right)^{.52} \left(\frac{C_p\mu}{k}\right)^{.3} \quad \ldots\ldots (7)$$

which, with a maximum error of 3.5%, reduced to,

$$\frac{hD}{k} = .47 \left(\frac{DV\rho}{\mu}\right)^{.52} \left(\frac{C_p\mu}{k}\right)^{.3} \quad \ldots\ldots\ldots (8)$$

Equation 8 can be used for either liquids or gases when the Reynolds number exceeds 200; for lesser values equation 6 is recommended for liquids and equation 7 for gases.

Boelter, Cherry and Johnson ("Heat Transfer Notes," University of California Press) give a general equation for liquids or gases when the Reynolds number is greater than 31,

$$\frac{hD}{k} = .437 \left(\frac{DV\rho}{\mu}\right)^{.437} \left(\frac{C_p\mu}{k}\right)^{.33} \quad \ldots\ldots\ldots (9)$$

A somewhat similar equation is suggested by Stoever ("Applied Heat Transmission," McGraw-Hill Book Company, 1941) for liquids at Reynolds numbers exceeding 100,

$$\frac{hD}{k} = .385 \left(\frac{DV\rho}{\mu}\right)^{.56} \left(\frac{C_p\mu}{k}\right)^{.30} \quad \ldots\ldots\ldots (10)$$

This equation reduces to,

$$h = .385\ (V^{.56})\ (D^{-.44})\ (\rho^{.56} k^{.7} C_p^{.3} \mu^{-.26}) \quad \ldots\ldots\ldots\ldots (10a)$$

and has been selected as the equation for use in constructing all graphical solutions for heating or cooling of liquids flowing outside and normal to a single pipe.

Graph for Water Outside a Pipe

The graph Fig. 2 is identical in form with Fig. 1 for water within a pipe. Its use is indicated by the following example, solution of which is shown by the dashed line on Fig. 2.

Example: Water at 100F is being heated (or cooled) while flowing at 3.4 fps outside and normal to a single 4 in. outside diameter pipe. Determine the external film coefficient of heat transfer.

Solution: Enter the graph at 3.4 fps and rise to the horizontal line for a 4 in. pipe (see dashed line on graph); then follow a direction line to intersect the scale, rise from this intersection to the horizontal marked 200F and return along a direction line to intersect the base scale at the answer, 540 Btu per hr per sq ft per F.

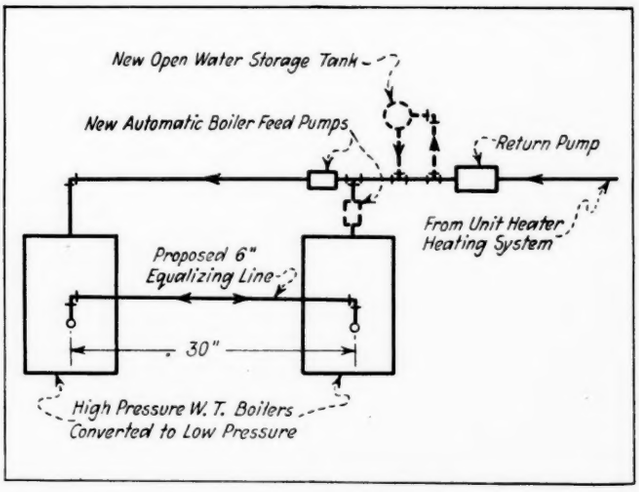
Steam Changes when Converting from High to Low Pressure

With the passage of time high pressure steam boilers depreciate, so that insurance companies stipulate the carrying of lower steam pressures; finally it becomes advisable to convert the heating plant to low pressure, especially so as less skilled labor is then required. The sketch illustrates such a condition and the changes recently made in a boiler plant to insure a safe and proper return of condensate from the heating system.

Boilers of the the type in question contain very little of water between high and low operating water levels in comparison with the balance of the heating system, so that it is quite difficult to maintain equal and stabilized water levels within them if the water is pumped directly to them by a single pump and without the routing of the water first to a return water tank of sufficient capacity to store the water for use as required in the boilers. In the installation shown, the boilers can quickly supply the heavy demand of the unit heaters whenever heating is required, but the return of water to the boilers is slow and irregular as the heating system has long distributing lines from a considerable floor area.

Operating conditions were not found so troublesome with only one boiler on the line, as in the Spring and Fall, but in Winter, with both boilers operating, considerable fluctuations of water to the boilers occurred whenever pumping directly to them. Boilers could, of course, have been equalized to a certain extent by the proposed cross connection shown in the sketch, but these boilers are 30 ft apart on centers and the distance from steam chamber to mud drum is 20 ft.

In the final changes an automatic boiler feed pump was provided for each boiler and the storage tank installed as shown. This tank offered still other advantages in that it provided a convenient place for charging make-up water as well as for the introduction of boiler compound as required for the elimination of scale.—*T. W. Reynolds.*


New Open Water Storage Tank
New Automatic Boiler Feed Pumps
Return Pump
From Unit Heater Heating System
Proposed 6" Equalizing Line
30"
High Pressure W. T. Boilers Converted to Low Pressure

Correcting a bad operating condition due to conversion of steam heating system from high to low pressure.

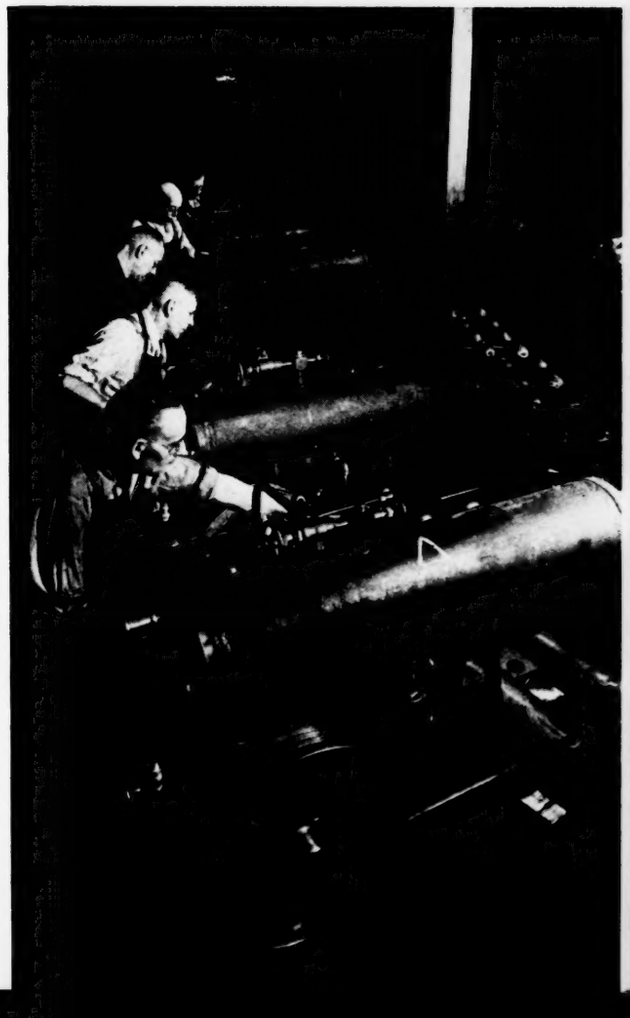
Picture Paragraphs

A brief record of novel developments

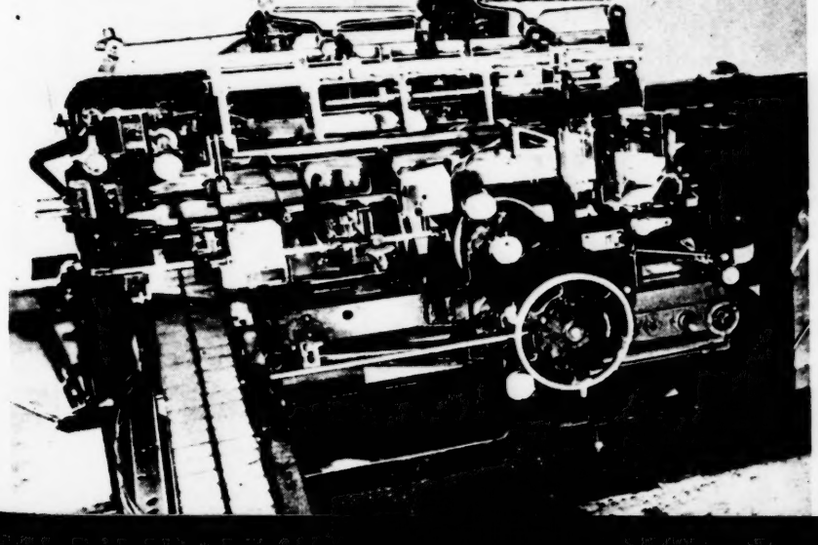
School children of the Caledonia School, Cleveland, are in an atmosphere of disinfected air. Three germicidal General Electric lamps are mounted above the blackboards. One 30-watt lamp will kill 90% of the pathogenic bacteria in 700 cu ft of air in one minute. Lamps are also used in military hospitals.

This is Mr. Wickel. Overnight, through the medium of a Truth or Consequence radio program, his serene existence as a representative of the Fitzgibbons Boiler Company was changed. He became a national character. More than 400 articles appeared about him in eastern newspapers. The radio program still continues to feature his efforts to obtain the $1,000 willed him by the late Peckinpaw Wickel.

A bank of water-cooled condensers for industrial refrigeration equipment is lined up in the plant of the York Corp., for testing. In peacetime, this machinery will help to cool hotels, department stores, theatres and other large occupancies. At present the units will be used as part of the war program.



A machine that normally wraps food will soon be used for packaging a fuel, in cube form, made from anthracite and bituminous fines, and held by an asphalt binder. A paper wrapped package of 6 cubes will weigh 7½ pounds.



NEWS OF THE MONTH

ICI Has Buffalo Chapter

BUFFALO—The Air Conditioning Council of Western New York, according to W. E. Voisinet, president, has become the first local chapter of Indoor Climate Institute. The formal induction ceremony was held at the Buffalo University Club November 14. The name of the local organization will be changed to Indoor Climate Institute, Western New York chapter.

Mr. Voisinet pointed out that the Air Conditioning Council of Western New York has been operating for eight years and has pioneered much of the same work that is being done by the Indoor Climate Institute. "Our members voted to join forces with the national I.C.I. in order to reinforce and broaden our public information and training programs," Mr. Voisinet said.

P. B. Zimmerman, vice-president of Chrysler Corporation, Airtemp Division, and president of Indoor Climate Institute, was the principal speaker at the Buffalo induction ceremonies.

ACRMA Sectionalizes

HOT SPRINGS, VA. — The Air Conditioning and Refrigerating Machinery Association, Inc., meeting here November 2-3, embarked on a new program under a sectionalization arrangement whereby the activities of the Association are broken up into five sections as follows: Air conditioning units; smaller compressors and condensing units; central station air conditioning and refrigeration equipment; room coolers; and large compressors and condensing units. The exact position of the line of demarcation between the room cooling and self-contained air conditioning units was not formally established at the organization meeting of the section but it may be somewhere at approximately the 2 hp line, although it was suggested that the division be made on an output rather than an input basis.

The smaller compressor group will include compressors up to and including 20 hp excepting ammonia compressors which, regardless of size, will be covered by the larger compressor and condensing unit section. It is the objective of the Association to obtain further membership of manufacturers in all groups and especially among those making smaller compressors.

One of the purposes of sectionalizing the meetings is to enable a manufacturer who makes a specialized rather than a diversified line of equipment to spend his time at meetings discussing subjects of interest to him rather than listening to papers and discussions on equipment which he is not involved with in any way. Each section will have its own engineering and standards committee and these committees will operate in collaboration with the Association's engineering and standards general committees so as properly to handle overlapping activities.

Goodman, Heitzler, to Speak in New Orleans

NEW ORLEANS—Louisiana Engineering Society will hold its annual meeting here January 11-13. Speakers on the program and their subjects include the following: A. H. Heitzler, Assistant Chief Engineer, Cities Service Refining Corporation, Lake Charles, La., "Supplying Large War Plants with Power, Water, Gas and Compressed Air"; William B. Goodman, Illinois Institute of Technology, "Dehumidifying of Air with Coils." Both Mr. Heitzler and Mr. Goodman will present their papers January 12.

Adopt Standards for Gas Heat

TOLEDO—The Association of Gas Appliance and Equipment Manufacturers has approved a set of standards covering controlled temperatures, controlled air circulation, humidification and air filtering for houses, so that any house built according to these standards will receive the association's certification of satisfactory performance, if members' equipment is installed. The standards will be available to architects, house builders, heating contractors and home owners.

To some extent, the heating standards set by the manufacturers follow the Certified Performance plan for gas ranges. The heating units of the manufacturers must pass minimum requirements of American Gas Association in addition to the certified quality in order to qualify in the certification plan.

Members of the association's certified heating performance committee are E. A. Weaver, Surface Combustion Corp.; W. L. Seelbach, Forest Cities Foundries Co.; Gordon Rieley, Bryant Heater Co.; R. W. Clewell, Richmond Radiator Co.; Elroy Payne, Payne Furnace & Supply Co.; R. L. Blodgett, Pennsylvania Furnace Co.; Frank Faust, General Electric Co.; Harold Massie, American Radiator & Standard Sanitary Co.; and J. R. Scott, Mueller Furnace Co.

L. A. Seeks to Abate Smoke

LOS ANGELES — The Los Angeles County Board of Supervisors has ordered the drafting of an ordinance, which is to be recommended for adoption also by the 45 communities of the county, as a county-wide measure for regulating smoke and fumes emanating from industrial plants.

The action of the board was taken following a final report from the County Smoke and Fumes Commission, appointed by the supervisors in October, 1943, to make a study of the smoke nuisance.

Officials of five manufacturing firms in Los Angeles, who were cited for court appearances on charges of causing a public nuisance by permitting an exceptionally large volume of smoke and noxious fumes to emanate from their plants, have contended that neither manpower or equipment is available at present to install smoke and fume control devices.

Beglen Reelected by PHIB

CHICAGO—That education is the basis of all selling was the theme of the 25th annual meeting of the Plumbing and Heating Industries Bureau at the Palmer House here October 26. Following a business meeting in the afternoon, members of the Bureau attended a dinner in the evening given by The Central Supply Association, on behalf of the plumbing and heating industries, in honor of the Bureau's silver anniversary. More than 650 attended the dinner. In his report as president of the Bureau, Harry F. Beglen said: "Today customers are looking for goods. Tomorrow goods will be looking for customers. It is to that tomorrow that today's Bureau publicity is directed." Mr. Beglen, who is district sales manager of the American Radiator and Standard Sanitary Corporation in Chicago, was re-elected president of the Bureau. Other officers re-elected are: Henry S. Blank of Dayton, Ohio, director and former president of the National Association of Master Plumbers, vice-president; E. N. McDonnell, Chicago, president of McDonnell & Miller, treasurer; and Norman J. Radder, Chicago, secretary.

Engineering Serial

Each month, during the past year, Tube Turns' advertisements have pointed out one single outstanding advantage of Tube-Turn seamless welding fittings. Added together, they have told a serial story of Tube-Turn engineering and performance qualities that are of prime importance to everyone concerned with designing, specifying, buying or installing piping and fittings.

Selected Tube Turns Distributors in every principal city are ready to serve you from complete stocks.

TUBE TURNS (Inc.) Louisville, Kentucky. Branch Offices: New York, Chicago, Philadelphia, Pittsburgh, Cleveland, Dayton, Washington, D. C., Houston, San Francisco, Seattle, Los Angeles.

TUBE-TURN
TRADE MARK
Welding Fittings and Flanges

Detroit Edison Sees Energy Use Upped

DETROIT — The Detroit Edison Company has set its sights to spend $125,000,000 during the ten years after the war to keep pace with demands for electricity in the area, James W. Parker, president and general manager, has announced. Mr. Parker disclosed that a new 75,000-kilowatt, 100,000-horsepower turbo-generator is on order.

Mr. Parker estimated that by 1950 average residential customer appliance use should increase to 1,257 kilowatt hours from a present usage of 702 kilowatt hours. This increase will result from a greater use of such things as: electric water heaters, frozen food devices, electric cooking equipment, home cooling and heating devices, television, incinerators, dishwashers, fireplace equipment, clothes dryers, home dust collectors, de-humidifiers, sun and sterilizing lamps.

In the industrial field new developments and techniques are in their infancy and should have wide general use after the war and Mr. Parker listed high-frequency and industrial heating for metals and dielectric heating of non-metallic materials, induction heating to anneal metal tubing and sheet, brazed tool tips and other objects; infra red drying of paints and lacquers; resistance welding; cleaning of air and electro-static deposit of fine particles in painting operations.

Dust Collecting Discussed

NEW YORK—A symposium, on dust collection was held at the 1944 annual meeting of the American Society of Mechanical Engineers, held here November 27-December 1. The symposium, held under the auspices of the Power Division, was presided over by M. C. Engle, assistant superintendent of engineering, Boston Edison Co., with H. E. Macomber, The Detroit Edison Co., as recorder.

Talks were made by Louis C. Whiton, president, Prat-Daniel Corp., who classified the types of dust collecting equipment now available; Richard F. O'Mara, sales manager, Western Precipitation Corp., who spoke on analysis of dust data and presentation of analyses in graphical form; H. C. Dohrmann, chief engineer, Buell Engineering Co., Inc., who described the various types of collectors made by his company; and Charles E. Beaver, sales engineer, Research Corporation, who reviewed the history of the Cottrell precipitation collectors.

Central Heating for Escanaba

CHICAGO—Escanaba's city council is considering a plan which, if adopted, will make the Michigan community the second city in the nation to heat all of its homes, stores, schools and churches from one central heating plant. Escanaba, with 15,000 population, already has made a start in this direction, constructing a small central heating plant in 1937 to serve a limited number of customers in the downtown area, the International City Managers Association reports.

Local interest in the municipal service led the city council recently to ask for a survey and recommendations by the city manager with regard to expansion of the central heating system to include the entire community.

The association points out in this connection that Virginia, Minn., early this year became the first city in the country to go on complete central heating, using a municipally-owned heating plant operated on a non-profit basis.

The Escanaba survey showed that community-wide heating by the central unit was feasible from economic and engineering standpoints, and that such a system could meet operating and maintenance costs, taxes and depreciation. To supply the entire system with heat would require a capital outlay of $3,190,000, about a third of this amount for plant and two-thirds for distributing mains.

Operating costs for the enlarged system are estimated at $240,000 yearly compared to present expenditures of about $305,000 by individuals and private concerns for coal for individual heating units. Annual revenue from steam at 78 cents per 1,000 pounds and sale of electricity generated by the steam turbines would total $531,000, but the net profit would be small because annual capital costs—taxes, depreciation and interest on investments—total more than $240,000. Capital costs would be reduced materially if the project is financed in part by special assessment.

5 Year Construction Boom Forecast at James Stewart Co. 100th Anniversary

NEW YORK—The greatest construction boom the United States has ever known, one that will last for five years, is a post-war certainty, Harry D. Watts, chairman of the board of James Stewart & Company, international engineers and contractors, said November 15 at a meeting marking the 100th anniversary of the company. The company has built over $250,000,000 worth of war plants in the past three years.

"You'll see virtually all factories 100% air, light and noise conditioned," said Mr. Watts. "Industrialists know that the better they keep working conditions, the better men they will attract and the better work and higher production will be turned out. Indeed, post-war air and lighting conditions will border on the sensational. Factory-caused colds, headaches and eyestrain will be virtually unknown. Absenteeism will drop tremendously.

"The American construction industry is ready to start work tomorrow," said Mr. Watts. "Schools, bank buildings, hospitals, and other institutions are on order throughout the country. Of the hundreds of war factories rushed to completion, a great many were built to last only five years and cannot handle post-war reconversion jobs. Many of them will have to be scrapped or entirely rebuilt."

Carrier Granted Conduit Patents

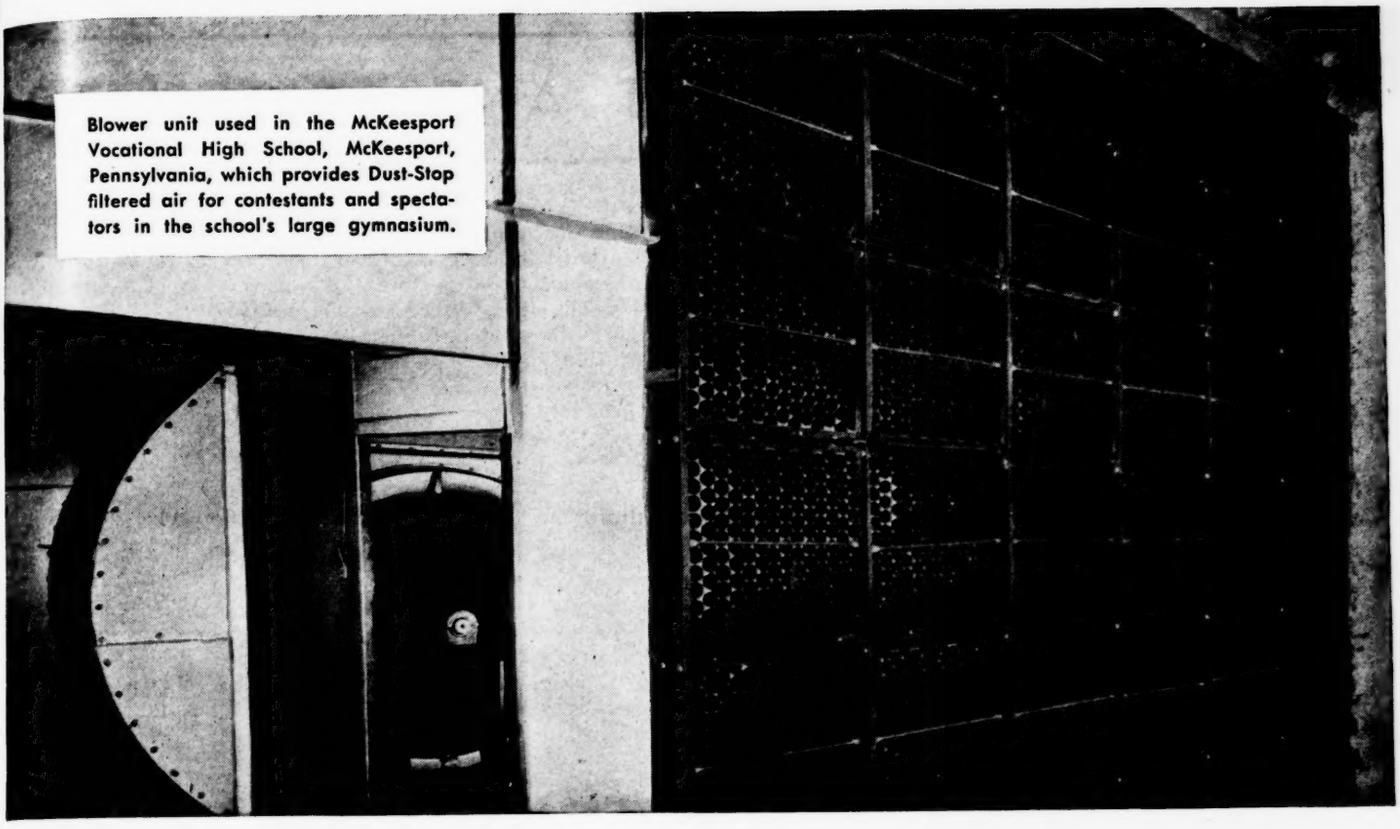
NEW YORK—Final patents on the Conduit Weathermaster air conditioning system have been issued to Carrier Corporation, Dr. Willis H. Carrier made known here November 29. Dr. Carrier, Chairman of the Board of Carrier Corporation, speaking before a group of editors and writers at the Waldorf-Astoria Hotel, declared the Conduit Weathermaster system, covered by the patents, would open up "vistas in the economic and social avenues of human progress which may do much to change our mode of life." [The Conduit system was described in HEATING AND VENTILATING in the July, 1941, issue.]

Beman Appointed

BUFFALO, N. Y.—Myron C. Beman of Beman & Candee, heating and ventilating engineers, has been appointed a member of an advisory committee to the new Department of Mechanical Engineering at the University of Buffalo.

Thomas Midgley, Jr.

NEW YORK—Thomas Midgley, Jr., who discovered the antiknock properties of tetraethyl lead and who was a co-developer of Freon refrigerants, died suddenly at his home in Worthington, Ohio, November 2, at the age of 55.



Blower unit used in the McKeesport Vocational High School, McKeesport, Pennsylvania, which provides Dust-Stop filtered air for contestants and spectators in the school's large gymnasium.

Filtered Air has gone to School

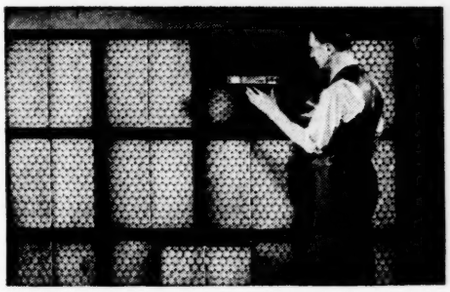
Filtered air, by itself, is no longer enough. Operating efficiency and economy are now "required subjects", wherever dust control and air conditioning are considered for today or tomorrow.

Dust-Stops* have passed the tests, with flying colors, in scores of schools and factories, in commercial buildings and institutions, and on many types of machinery and equipment.

The Dust-Stop Air Filter is made of packs of glass fibers coated with an adhesive, faced with metal grilles and bound on the edges with a fiberboard frame.

The high efficiency of Dust-Stop Air Filters is made possible by the Fiberglas filter medium and the nonodorous, nonevaporating adhesive. Due to extraordinary wetting power each particle of dust acts as a wick to carry adhesive to other particles. Therefore, the effectiveness of the Dust-Stop is maintained until it becomes heavily coated with dust.

Dust-Stops are readily available in nearly every community. And replacement is easy, quick, inexpensive.



Dust-Stops for central systems comprise individual parts for each cell; steel frames, bolts, nuts, gaskets and filters—complete and ready for assembly.

Write for complete information about Dust-Stops and the type of installation best adapted to your requirements. There is no obligation. Address: *Owens-Corning Fiberglas Corporation, 1912 Nicholas Building, Toledo 1, Ohio. In Canada, Fiberglas Canada Ltd., Oshawa, Ontario.*

ARMY E NAVY

DUSTOP AIR FILTERS

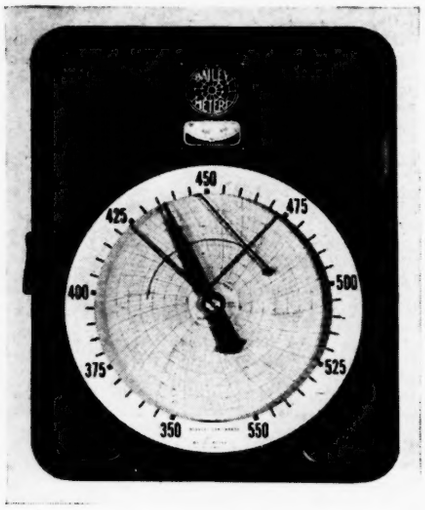
*T. M. Reg. U. S. Pat. Off.

—a FIBERGLAS product

NEWS OF EQUIPMENT AND MATERIALS

Electronic Thermometer

NAME — Electronic type resistance thermometer.
PURPOSE—For indicating, recording, controlling temperatures between —100F and 1000F.



FEATURES—Recorder operates on null balance principle and provides instantaneous balancing action by electronic detection and control. Unbalance of the measuring bridge is detected by electron tubes without aid of galvanometer or other moving parts. Reliable performance and accurate calibration over long periods of continuous operation are said to result from sturdy design. Has 29 in. indicating scale. May be provided with as many as 4 recording pens, each one with its own continuously controlled electronic control and measuring bridge. Alarm contacts may be provided for any or all of the recorder unit. Temperature measuring circuits may be arranged to calculate sum, difference and ratio of temperatures. Calculated results are recorded directly by electronic type recorders in form of news instead of history. Much time and labor may be saved by electronic calculating method as compared with manual calculation from chart records and log sheets.
MADE BY — *Bailey Meter Co., 1050 Ivanhoe Road, Cleveland, Ohio.*

Welding Galvanized Sheets

NAME—Galv-weld.
PURPOSE—To regalvanize a seam after a weld has been made.
FEATURES — After the galvanized sheets are welded, and while the metal is still hot, the weld is brushed with an iron brush to remove scale, and then a stick of the galv-weld alloy is rubbed over the welded seam. While still liquid, the alloy is brushed to spread it evenly along the seam. Result is a smooth galvanizing job along the weld. Alloy melts at 450F. Designed to coat defective spots in galvanized sheets and pipe.
MADE BY—*Galv-Weld Products, 305 E. 2nd St., Dayton, Ohio.*

Hand Searchlight

NAME—Big Beam No. 41 portable electric hand searchlight.
PURPOSE—To provide a strong portable searchlight, with a battery that can be recharged.
FEATURES—Will project a beam of light more than 2,500 ft; by adding a snap-on lens, the light is dispersed over a wide area. Light is powered by a heavy duty 6-volt storage battery that can be recharged easily from any d-c or a-c source. Lamp head can be turned in any direction.

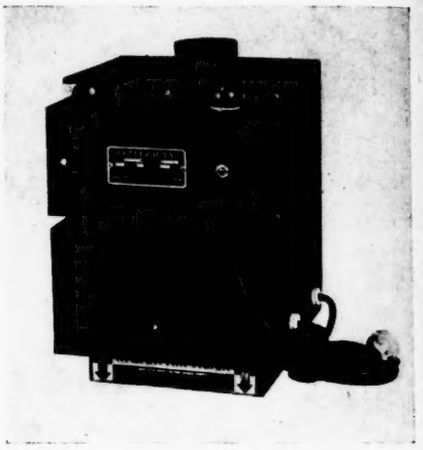
MADE BY—*U-C Lite Manufacturing Co., Chicago 11, Ill.*

Connector for Sheet Metal

NAME—Sheetlock.
PURPOSE—Self-fastening connecting strips for connecting metal sheets.
FEATURES—The locking strip is a double channel with indented louvers or notches, spaced uniformly at 12 deg. angle along the sides of the strip. Protruded louvers are made along the edge of the sheets, spaced and angled the same as the strip. Sheets are pushed into the channel, and slid parallel to the strip until the louvers engage to form a wedged lock. To disengage, reverse the procedure. Strip comes flat for straight connections and angles for corner connections.
MADE BY—*The Sheetlock Co., 4529 N. Clark St., Chicago 40, Ill.*

Ozo-Ray

NAME—Ultraviolet Ozo-Ray.
PURPOSE—For air purification by ultraviolet rays.



FEATURES—Circulating air is passed through the ultraviolet field created by the Ozo-Ray generating unit so that the air is ionized. Electric field surrounding the elements further activates the ionized air so that impurities in the air are oxidized. Generating unit consists of plastic element and is said to operate without arcing, sparking or destructive heat. Device can be installed in ducts or in a single room. Where the Ozo-Ray unit is inconveniently located a remote control is available.
MADE BY—*A & J Company, 844-848 W. 59th St., Chicago 21, Ill.*

Airco Hi-Bond

NAME—Airco Hi-Bond.
PURPOSE—To aid uniformly successful tinning of cast iron prior to brazing.
FEATURES — Product overcomes difficulties usually encountered in tinning cast iron due to its graphitic nature and makes possible highly satisfactory tinning of cast iron especially of high carbon and silicon content or low combined carbon analysis. Flux does not take the place of regular flux used for actual brazing operation.
SIZES AND CAPACITIES—Available in one pound glass containers.
MADE BY — *Air Reduction Sales Co., 60 E. 42nd St., New York 17, N. Y.*

SATISFYING THE WORLD'S TOUGHEST CUSTOMER

Fittest of the Fleet

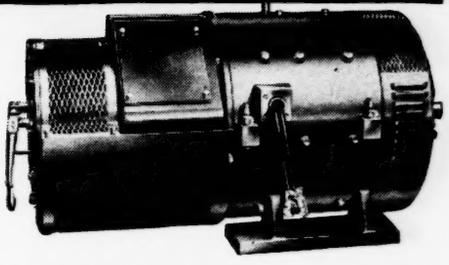
THEY'RE the Fittest of the Fleet – the volunteers who man U. S. submarines.

Relatively few men have the physical stamina, the mental alertness, the iron nerve, that admit them to the submarine service.

Because equipment must match the men, everything that goes into the making of a submarine is built to the strictest specifications on record – must pass careful inspection, endless testing. Knowledge that safety of the submariners depends upon the ability of equipment to stand up under strains of year-long voyages and shocks of battle makes Navy engineers and purchasing agents "tough customers" to satisfy.

Star began building equipment to satisfy these "tough customers" in World War I, and long before Pearl Harbor, resumed making of motors and motor generators for the U. S. Navy. While the Navy does not endorse any product the fact that Star equipment has met and exceeded U. S. Navy specifications for submarine use is positive proof of the engineering ability of this organization.

That engineering ability, developed in years of service for "the world's toughest customer", is at your service in solving peace-time motor problems. Star Electric Motor Company, 200 Bloomfield Ave., Bloomfield, New Jersey.



What's your special motor problem?

American submarines have a better chance of escaping enemy detection while running submerged because of the Star steering gear motor (above). Extremely quiet operation is achieved by advanced design, including use of a special Star internal expanding shoe brake built integral with the motor. Twelve other types of Star motors are used on U. S. submarines.

Star's Navy record is proof of our ability to handle your difficult motor problems. If a standard Star motor (⅛ to 200 H.P.) does not meet your needs Star can build one that will! We are ready to discuss your post-war plans now.

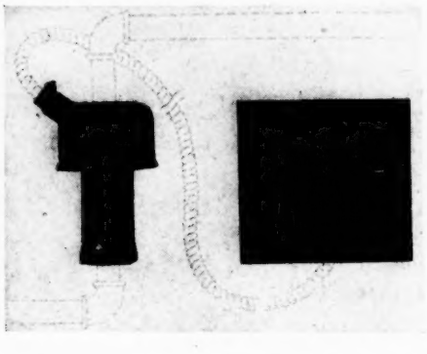
ARMY ★ E ★ NAVY

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

Level Float Control

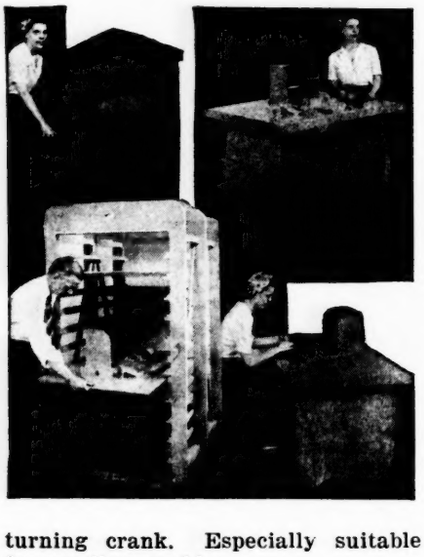
NAME—Hancock level float control.
PURPOSE—An electrical device for controlling liquid levels.
FEATURES—Instrument has no levers,



linkages, or wearing parts. By adjusting a screw, the level of the liquid can be raised or lowered.
LITERATURE AVAILABLE—20-page catalog fully describing this device.
MADE BY—*Manning, Maxwell & Moore, Inc., Bridgeport 2, Conn.*

Work Table

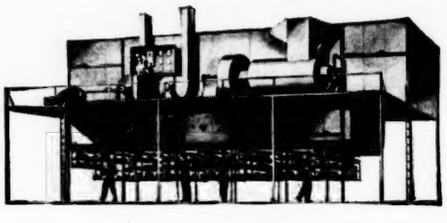
NAME—Rightop work table.
PURPOSE—Work bench with removable top so that up to 12 jobs may be kept "on the boards" at one time.
FEATURES—Top raises and tilts. Top is removable and can be left off and slid into rack until needed again so that work in process need not be displaced. Adjustable in height by



turning crank. Especially suitable for small assembly.
MADE BY—*Voss Machinery Co., 2834B W. Liberty Ave., Pittsburgh 16, Pa.*

Despatch Core Oven

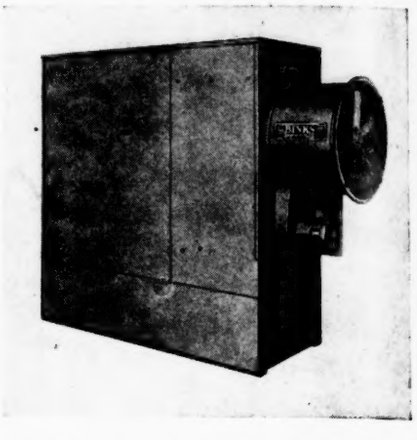
NAME — Despatch conveyor foundry oven.
PURPOSE—For core baking.
FEATURES—Designed with four levels of horizontal core travel. Cores are loaded in open section, then travel vertically to baking oven at top where they make two horizontal passes in heating system. As the cores enter third horizontal level they pass through a cooling zone so that as the units come out of that zone and enter the unloading station the cores are cool enough to handle. Heating is by a direct-fired combination gas-oil heater. Air is circulated through oven by steel blade fan. There are two additional fans, one an exhaust fan to remove fumes from baking zone of oven, other exhaust fan which is connected to cooling system so that cores may be brought down to the proper temperature for handling when they reach lower level. Core oven system has 36 carriers each of which has four adjustable shelves. Conveyor speed is



adjustable to provide from one to four hour baking time as required for the size of core being baked. System has automatic temperature control and all approved safety equipment.
SIZES AND CAPACITIES — Oven has capacity for 50,000 lb of core per 8 hours with temperatures from 450 to 650F. Capacity of heater is 3 million Btu per hour with allowance for 25% overload. Ovens of this type may be arranged in practically any size and capacity to meet any foundry requirements and loads.
LITERATURE AVAILABLE—Bulletin No. 30.
MADE BY—*Despatch Oven Co., Minneapolis 14, Minn.*

Binks Type 2D Cooling Tower

NAME—Binks 2-D small series induced draft cooling towers.
PURPOSE—For general water cooling applications, including air conditioning and refrigeration.
FEATURES—Galvanized materials used throughout. Frames are of non-corrosive aluminum alloy, motors are of splash proof design. Spray principle distribution of water is used. Fan is of aluminum-alloy propeller-type for induced draft, with air supply obtained through rear. Nozzles are of Rotojet type, water connections easily accessible in front of tower. V-belt drive. In larger sizes heat exchange coils may be located in spray zone for direct cooling of water for diesel engine jackets, for cooling, quenching oil, or temperature control of industrial processes.
SIZES AND CAPACITIES — Made in single fan type in 11 sizes with capacities ranging from 3 to 150 gpm and

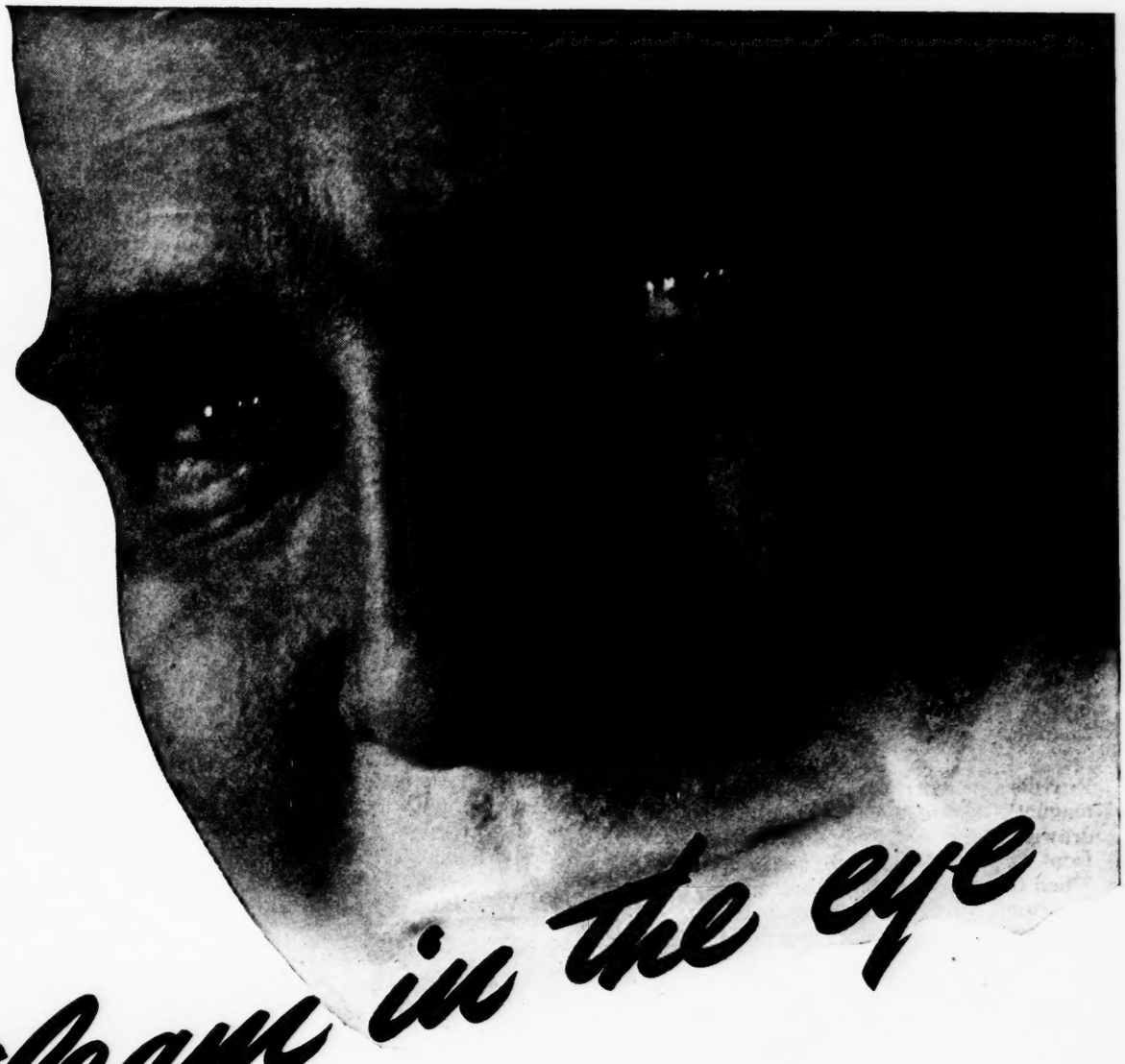


for installations from 1 to 50 tons of refrigeration based on three gallons per minute per ton at a 10F rise. Also available in 5 twin frame sizes with capacities from 180 to 300 gpm for 60 to 100 tons installations. Illustration shows single fan type.
LITERATURE AVAILABLE—Bulletin 600.
MADE BY — *Binks Mfg. Co., 3114-40 Carroll Ave., Chicago 12, Ill.*

Electronic Relay

NAME—CR7511-A electronic relay.
PURPOSE—A relay to permit pressureless switching and the avoidance of arcing and sticking of contacts.

FEATURES—Basically this is an electronic tube amplifier which has an input and output circuit. An electromagnetic relay is connected in the output circuit of the electronic tube and the relay is used to operate the equipment.
LITERATURE AVAILABLE—Electronic Relay (GEA-4214) describes and illustrates applications of this relay.
MADE BY—*General Electric Company, Schenectady, N. Y.*



Gleam in the eye

What's the state of your postwar product . . . or project? Is it just a gleam in your eye—a sketch on a scratch-pad—or a design on the drawing board?

Whatever stage it's in, you can profitably give thought to sheet steel as the material to use. What other material offers so much—such workability and versatility, such strength for its weight and volume—at so little cost?

Bethlehem makes sheets for all purposes. Deep-drawing sheets, capable of being formed in ways that were undreamed-of a few years ago. Galvanized sheets for ductwork, roofing and many other uses. Sheets for painting, enameling and special finishes. Beth-Cu-Loy (copper-bearing) sheets that provide two to three times ordinary corrosion-resistance. Mayari R sheets, rolled from Bethlehem's high-tensile, corrosion-resisting, low-alloy steel. And many others.

Let's put our heads together over your present and future plans. Let us help you in determining where and how sheet steel could be used to your advantage in the products you'll be making after the war. Get in touch with the nearest Bethlehem district office or write to Bethlehem Steel Company, Bethlehem, Pa.

BETHLEHEM STEEL

Bethlehem Steel Sheets

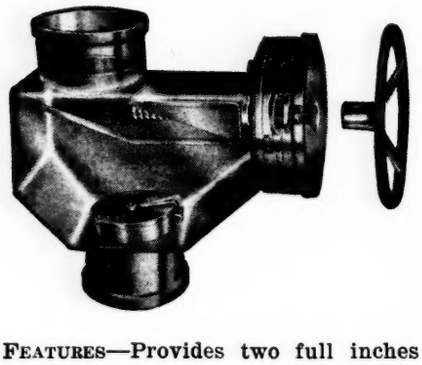
Motor Starting Switch

NAME — Split-phase motor starting switch.
PURPOSE—To start a split-phase motor of any size, with or without capacitators.

FEATURES—Device is activated by the magnetic field of the motor. Power is drawn from the stator through two iron poles inserted into the stator. When the poles are energized, an arm is swung into position and electrical contact is made. This engages the starting winding. The cut out of the starting winding can be made at the usual 1450-1500 rpm, or at any desired critical speed. The switch is adjusted at the factory to cut in and out at any desired speed. A spring forces the arm away from the pole pieces instantaneously when the magnetic force drops. Each switch is hermetically sealed.
MADE BY—*Motor Controls, Inc., 469 E. Ohio St., Chicago 11, Ill.*

Drainage Control Valve

NAME—Boosey drainage control valve 109.
PURPOSE — For protecting basements from back flooding of street sewers.



FEATURES—Provides two full inches of lip clearance for automatic bronze swing check valve, so that floating objects ordinarily will not interfere with proper seating. As a positive method of controlling the basement openings, a manually-operated bronze gate is provided. As gate does not require a recess for seating, packed sewage solids cannot prevent complete closing. Unit installs flush with the floor and is therefore readily accessible for cleaning and inspection.
MADE BY—*Norman Boosey Mfg. Co., Div. of American Skein & Foundry Co., 420 N. La Salle St., Chicago 10, Ill.*

Attic Fan Blades

NAME—Armco Cold Rolled Paintgrip. blades.
PURPOSE—Redesign of the company's A series blade.
FEATURES — Efficiency has been improved; identical proportions, proved aero-dynamically correct, are adhered to in all diameters. A larger center disc and heavier spider arms increase strength. A new blade shape adds to the appearance. Entire line is of all steel construction.
SIZES AND CAPACITIES — Available in either 3, 4, or 5 blades in standard diameters of 24, 30, 36, 42 and 48 in.
LITERATURE AVAILABLE — Temporary bulletin.
MADE BY—*Torrington Mfg. Co., Torrington, Conn.*

Metal Coloring

NAME—Metal coloring process.
PURPOSE — For coloring by simple processes of chemical immersion, steel, copper, brass, bronze, zinc, nickel, tin, gold, silver, aluminum, magnesium and other metals and alloys.
FEATURES — A wide range of colors is possible in iridescent and matte effects. Many of the coloring baths also increase corrosion resistance of metal being treated. Coloring salts or solutions are furnished with instructions for use. Metal preparation and cleaning instructions are also given. It is suggested that samples of metal-to-be-colored be submitted, together with sample or description of color desired. A description of end-use of products is also desirable. Metal specimens will be colored and returned for evalution.
MADE BY—*Technical Processes Div., of Colonial Alloys Co., Philadelphia 29, Pa.*

Germitidal Lamp

NAME—Hygeaire unit.
PURPOSE—Air disinfection by ultraviolet rays.
FEATURES—Unit is a re-styling and new model of original unit. Has been re-designed by an industrial designer. Unit employs G. E. germicidal tube to project intensified ultraviolet rays across living or working areas above eye level. Reflector provides both optimum intensity and diffusion of the rays that are lethal to airborne bacteria. Unit may be recessed into

wall, or wall or ceiling suspended. Because more than 85% of the ultraviolet energy output of this new unit is of the germicidal wave length (2537 Angstroms) it is said to assist industry in combating absenteeism caused by cross infection in offices and plants.
MADE BY—*American Sterilizer Co., Erie, Pa.*
DISTRIBUTED BY — *The Graybar Electric Co. and General Electric Supply Corp.*

Sheet Steel

NAME—Armco Cold Rolled Paintgrip.
PURPOSE — A special surface-treated sheet steel that takes and preserves paint.
FEATURES — Metal sheet is given an electrolytic zinc flash and is then bonderized at the mill. With this sheet, products can be drawn or formed and painted immediately and no surface etching is required. The makers claim that it will draw, form, weld, and solder readily.
LITERATURE AVAILABLE — Booklet, "Armco Cold Rolled Paintgrip, Where and How to Use It."
MADE BY—*The American Rolling Mill Co., Middletown, Ohio.*

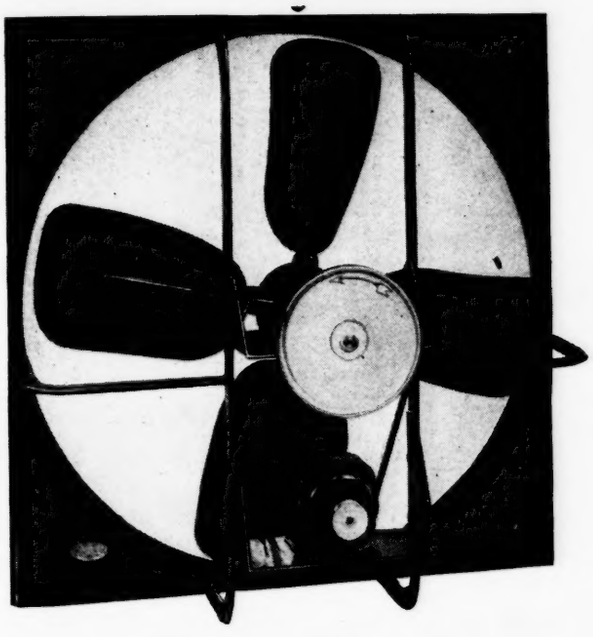
Aluminum Cabinets

NAME—Lindsay structure in aluminum.
PURPOSE—For cabinets and containers.
FEATURES — Aluminum structure, available as a complimentary product to the company's steel structure but does not replace steel structure. Manufactured of 61 ST alloy, aluminum structure with panel sheets of .020 in. or .025 in. thickness, possessing adequate rigidity for a wide variety of uses.
NAME — *Lindsay & Lindsay, 222 W. Adams St., Chicago, Ill.*

JOHNSON Health-aire PRODUCTS
Climate as you like it

Health-aire Belt Driven Propeller Fans...

Available in sizes 24 to 54 inches and capacities 4,500 to 25,000 C. F. M.



FOR "climate as you like it" . . . for a full measure of comfort and ventilation in all residential, commercial, industrial and public buildings, the Johnson **Health-aire** belt driven fan is your best bet!

Backed by 25 years experience in designing and manufacturing propeller fans and blowers, Johnson **Health-aire** belt driven fans combine the most advanced, the most effective engineering ideas.

For manufacturing plants, laboratories, offices, restaurants, hotels, grocery stores, auditoriums, churches, funeral homes and all other similar places, Johnson **Health-aire** fans are guaranteed to give the finest performance.

These fans are available in sizes 24 to 54 inches and in capacities of 4,500 to 25,000 C.F.M. Order Johnson **Health-aire** belt driven propeller fans for all your needs today!

Here are Health-aire Features:

- All steel welded construction
- Capacitor, long hour, resilient mounted motors
- Bronze, self-aligning bearings
- Dynamically and statically balanced for quiet operation
- Adjustable tension, over-powered drives
- Rated and tested in accordance with ASHVE and NAFM codes for propeller fans.

Are You Set for Next Spring Deliveries?

Johnson Fan & Blower Corporation invites your correspondence concerning delivery and distribution set up for next spring. Anticipate your requirements now! Write Johnson today for full details concerning our plan that will supply you with your needs for next spring and summer.

JOHNSON FAN & BLOWER CORPORATION

1321 WEST LAKE STREET • CHICAGO 7, ILLINOIS

Degree-Days for October, 1944

HEATING AND VENTILATING'S 16th year of publication of monthly degree-day data

City	Monthly Degree-Days			Cumulative Degree-Days[1]			Year[2]
	Degree-Days, Oct., 1944	Degree-Days, Oct., 1943	Degree-Days, Oct., Normal	Season, 9/1/44-10/31/44	Season, 9/1/43-10/31/43	Season, Normal, 9/1-10/31	Normal, 9/1-8/30
Abilene, Texas	52	70	0	52	78	0	2061
Albany, New York	434	466	446	561	656	518	6580
Albuquerque, New Mexico	200	250	273	221	264	273	4298
Alpena, Michigan	548	574	570	768	876	792	8299*
Anaconda, Montana	413	557	647	720	781	982	8357**
Asheville, North Carolina	289	316	276	289	430	276	4232
Atlanta, Georgia	134	170	96	138	193	96	2890
Atlantic City, New Jersey	256	269	254	287	338	254	5176
Augusta, Georgia	71	104	16	71	105	16	2161
Baker, Oregon	342	518	552	559	632	810	7163
Baltimore, Maryland	246	273	223	273	327	223	4533
Billings, Montana	337	384	524	529	553	713	7119
Binghamton, New York	502	489	453	624	684	561	6808
Birmingham, Alabama	89	173	0	89	193	0	2352
Bismarck, North Dakota	463	423	626	696	652	848	9192
Block Island, Rhode Island	324	304	279	383	393	279	5788
Boise, Idaho	222	371	434	352	408	536	5552
Boston, Massachusetts	363	355	363	453	475	411	6045
Bozeman, Montana	456	531	651	737	794	987	8521**
Buffalo, New York	467	512	419	586	703	494	6822
Burlington, Vermont	579	529	481	752	759	625	7514
Butte, Montana	500	617	655	844	912	999	8272
Cairo, Illinois	165	205	158	165	242	158	3909
Canton, New York	584	554	557	786	822	746	8020
Charles City, Iowa	432	501	476	564	747	569	7588
Charleston, South Carolina	46	66	0	46	66	0	1769
Charlotte, North Carolina	161	166	115	169	202	115	3120
Chattanooga, Tennessee	210	215	105	211	239	105	3118
Cheyenne, Wyoming	478	553	605	714	778	845	7466
Chicago, Illinois	373	363	350	450	530	350	5957
Cincinnati, Ohio	291	289	254	332	377	254	4684
Cleveland, Ohio	374	401	366	464	535	393	6155
Columbia, Missouri	203	284	260	235	366	260	4922
Columbia, South Carolina	94	107	31	97	114	31	2364
Columbus, Ohio	315	339	313	368	450	313	5398
Concord, New Hampshire	547	483	484	716	729	652	7353
Concordia, Kansas	209	334	276	255	396	276	5315
Dallas, Texas	30	83	0	30	84	0	2256
Davenport, Iowa	305	343	363	357	479	363	6289
Dayton, Ohio	342	350	273	396	480	273	5264
Denver, Colorado	306	344	428	393	437	500	5874
Des Moines, Iowa	284	374	357	354	534	357	6384
Detroit, Michigan	388	447	400	479	618	442	6490
Devils Lake, North Dakota	522	526	706	797	837	982	9970
Dodge City, Kansas	231	308	276	288	352	276	5035
Dubuque, Iowa	370	409	409	453	600	445	6790
Duluth, Minnesota	556	565	626	835	939	896	9443
Eastport, Maine	560	482	543	782	759	819	8520**
Elkins, West Virginia	452	474	378	591	689	441	5697
El Paso, Texas	49	61	40	49	75	40	2428
Ely, Nevada	(a)	564	(a)	(a)	734	(a)	—
Erie, Pennsylvania	390	432	378	390	569	414	6273
Escanaba, Michigan	580	549	591	793	892	834	8771*
Evansville, Indiana	273	284	155	294	368	155	4244
Forth Smith, Arkansas	55	150	62	55	150	62	3147
Fort Wayne, Indiana	419	436	347	520	639	347	5925
Fort Worth, Texas	24	73	0	24	76	0	2148
Fresno, California	19	106	19	20	106	19	2334
Galveston, Texas	5	28	0	5	28	0	1016
Grand Junction, Colorado	206	269	369	212	271	369	5548
Grand Rapids, Michigan	418	438	419	518	626	476	6535
Green Bay, Wisconsin	497	502	505	660	774	637	7825
Greensboro, North Carolina	247	257	143	271	325	143	3529
Greenville, South Carolina	155	179	146	168	212	146	3380
Harrisburg, Pennsylvania	359	356	329	418	465	329	5375
Hartford, Connecticut	430	405	344	517	534	392	6036
Hatteras, North Carolina	73	86	0	74	92	0	2571
Havre, Montana	408	469	620	607	700	890	8700
Helena, Montana	505	548	614	773	774	865	7898
Houston, Texas	8	39	0	8	41	3	1157
Huron, South Dakota	454	461	526	612	670	649	8004
Indianapolis, Indiana	292	306	298	326	418	298	5298
Jackson, Miss.	75	(a)	(a)	75	(a)	(a)	(a)
Kansas City, Missouri	145	283	219	168	343	219	4956
Kewanee, Illinois	305	384	334	346	554	412	6139
Knoxville, Tennessee	222	260	183	223	304	183	3670
La Crosse, Wisconsin	406	510	462	517	761	558	7322
Lander, Wyoming	521	536	654	770	727	930	7947

[1]Cumulative data identical with monthly figures for September only. In subsequent months, cumulative figures will show record for whole heating season to and including month in question.

[2]Figures in this column are normal totals for a complete heating season, September to June, incl.

Figures in this table, with nine exceptions, based on local weather bureau reports. Exceptions are Utica, Lewiston, Kewanee, Sioux City, and Jackson, figures for which are furnished through the courtesy of Coke Sales Department, Central New York Power Corp., Utica, N. Y.; Norman E. Ross, Bursar, Bates College, Lewiston, Me.; J. M. Hartman, Engineering Department, Kewanee Boiler Corp., Kewanee, Ill., Alfred R. Wagstaff, Engineer, Sioux City Foundry and Boiler Co., Sioux City, Iowa, and H. M. Ludlow, Box 1368, Jackson, Miss., respectively; Anaconda, Bozeman, Butte and Livingston, Mont., through the courtesy of the Montana Power Company.

[Table concluded on page 106]

BRANCH OFFICES

IN PRINCIPAL CITIES

MASSACHUSETTS

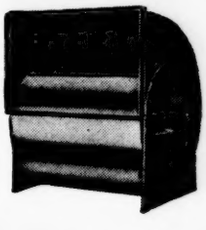
COMPLETE RANGE OF

SIZES & CAPACITIES

HEATING AND VENTILATING PRODUCTS

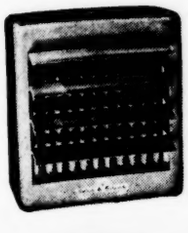
BLOWERS

Squirrel Cage type, Single and Double width. Sizes from 12" to 96" wheel diameter.



BLOWERS

Power Fixed Back Curved type, Single and Double width. Sizes from 12" to 75" wheel diameter.

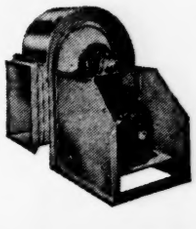


UNIT HEATERS

Propeller Fan type Unit Heater, both Horizontal and Vertical Projection type.

BELT DRIVE VENTILATING UNITS

Complete packaged units. Quiet, compact, for capacities 200 to 10,000 C. F. M.

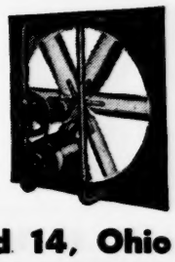


UNIT HEATERS

Blower Type, ceiling and floor mounting. Also available as ventilating units with filter and damper sections.

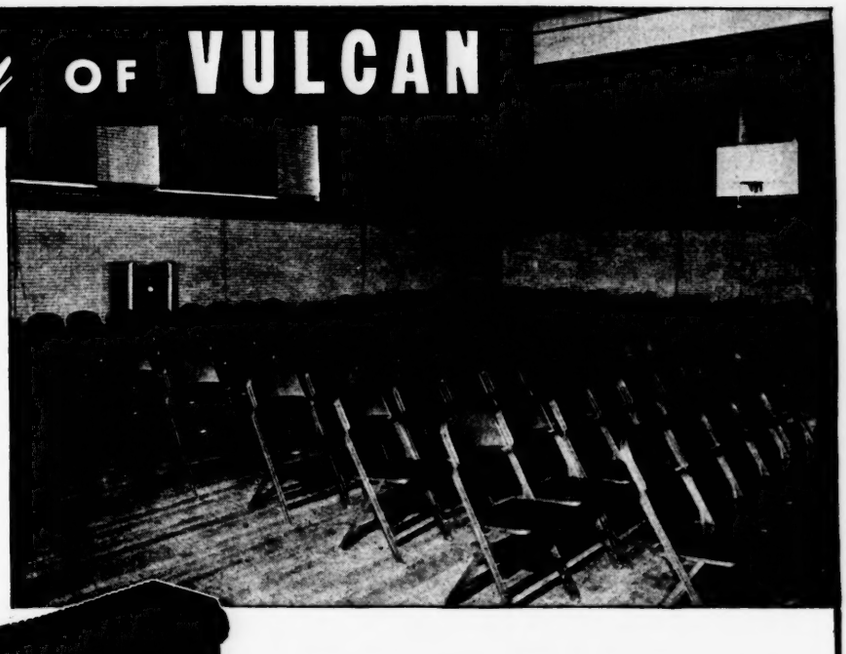
PROPELLER FANS

Belt Drive and Direct Drive types. Sizes 12" to 48". Accessory items consisting of Shutter and Fan Houses.



4901 Hamilton Ave. • THE BISHOP & BABCOCK MFG. CO. • Cleveland 14, Ohio

THE *Versatility* OF VULCAN



VULCAN, the accepted continuous line radiation, has proven extremely versatile in application. ***Here are some of its advantages:***

Light Weight. It is light and compact but strong and rigid. Sections come cut to length and ends are threaded or chamfered.

Uniform Heat. There is little temperature difference between floor and ceiling and horizontal temperature is uniform.

Greater Output. Maximum heat distribution is obtained with the Vulcan offset fin construction. One length of VULCAN 1¼" is equal to 8 pipes of the same length 1½" diameter.

Few Fittings. A large number of valves and fittings are eliminated by installing VULCAN.

VULCAN Radiation solved a heating problem in this auditorium. Radiators were installed easily up high out of the way. Down drafts were eliminated and even temperature control was maintained.

VULCAN—HARTFORD is stamped on every radiator.

SEND FOR CATALOG Showing Temperature Controls

THE VULCAN RADIATOR CO. **26 FRANCIS AVENUE, HARTFORD 6, CONN.**

RADIATOR MANUFACTURERS FOR ALMOST TWO DECADES

Degree-Days for October, 1944 (Concluded)

HEATING AND VENTILATING'S 16th year of publication of monthly degree-day data

City	Monthly Degree-Days			Cumulative Degree-Days[1]			Year[2]
	Degree-Days, Oct., 1944	Degree-Days, Oct., 1943	Degree-Days, Oct., Normal	Season, 9/1/44-10/31/44	Season, 9/1/43-10/31/43	Season, Normal, 9/1-10/31	Normal, 9/1-6/30
Lansing, Michigan	507	511	481	661	766	595	7048
Lewiston, Maine	556	510	501	742	771	666	7707
Lincoln, Nebraska	243	364	316	300	448	316	5999
Little Rock, Arkansas	87	140	47	87	143	47	2811
Livingston, Montana	439	435	523	747	648	750	7205
Los Angeles, California	34	49	0	39	49	0	1504
Louisville, Kentucky	229	234	186	245	295	186	4180
Lynchburg, Virginia	280	241	220	317	307	220	3980
Macon, Georgia	94	127	6	94	134	6	2201
Madison, Wisconsin	431	442	459	542	685	546	7429
Marquette, Michigan	525	545	567	769	879	792	8693*
Memphis, Tennessee	140	172	62	140	193	62	2950
Meridian, Mississippi	99	119	22	99	122	22	2160
Milwaukee, Wisconsin	430	456	450	512	691	534	7245
Minneapolis, Minnesota	431	480	481	565	716	574	7850
Modena, Utah	431	437	517	532	501	673	6562
Montgomery, Alabama	55	109	0	55	109	0	1884
Nantucket, Massachusetts	322	302	335	381	405	398	5957
Nashville, Tennessee	208	213	136	209	249	136	3507
New Haven, Connecticut	391	386	360	466	497	399	5895
New Orleans, Louisiana	13	60	0	13	60	0	1024
New York, New York	283	317	276	318	382	276	5347
*Nome, Alaska	742	781	744	742	781	744	14580**
Norfolk, Virginia	131	170	99	136	197	99	3350
North Head, Washington	245	328	366	469	536	621	5452**
North Platte, Nebraska	333	410	434	427	520	476	6366
Oakland, California	122	175	183	219	237	273	3143**
Oklahoma City, Oklahoma	75	145	105	85	146	105	3613
Omaha, Nebraska	258	381	329	320	489	329	6131
Oswego, New York	474	499	459	607	693	573	7088
Parkersburg, West Virginia	321	330	285	379	434	285	4775
Peoria, Illinois	338	354	381	407	505	384	6109
Philadelphia, Pennsylvania	254	279	242	285	328	242	4855
Phoenix, Arizona	0	24	0	0	24	0	1405
Pittsburgh, Pennsylvania	322	394	313	386	506	313	5235
Pocatello, Idaho	397	452	499	600	538	655	6655
Portland, Maine	542	492	477	734	732	639	7218
Portland, Oregon	201	279	332	281	309	437	4469
Providence, Rhode Island	331	349	348	392	461	411	6015
Pueblo, Colorado	333	428	388	400	518	394	5514
Raleigh, North Carolina	182	178	130	187	217	130	3234
Rapid City, South Dakota	384	417	515	533	586	659	7118
Reading, Pennsylvania	334	348	344	384	438	344	5389
Redding, California	(a)	164	19	(a)	164	19	2451
Reno, Nevada	380	461	453	529	514	597	5892
Richmond, Virginia	213	229	161	229	275	161	3695
Rochester, New York	491	507	431	625	700	503	6732
Roseburg, Oregon	185	285	350	258	312	461	4428
Roswell, New Mexico	138	170	186	157	188	186	3484
Sacramento, California	31	110	71	34	110	71	2653
St. Joseph, Missouri	172	302	248	208	377	248	5161
St. Louis, Missouri	173	219	205	190	275	205	4585
Salt Lake City, Utah	214	334	388	281	360	406	5555
San Antonio, Texas	16	42	0	16	52	0	1202
San Diego, California	25	32	34	31	32	34	1645
Sandusky, Ohio	350	375	353	421	496	353	6208
San Francisco, California	127	131	146	276	232	260	3264**
Sault Ste. Marie, Michigan	658	645	623	939	996	899	9285**
Savannah, Georgia	35	69	0	35	69	0	1490
Scranton, Pennsylvania	467	452	397	574	609	457	6129
Seattle, Washington	231	330	394	324	411	580	4934**
Sheridan, Wyoming	356	479	636	565	717	900	8008
Shreveport, Louisiana	58	90	0	58	91	0	1938
Sioux City, Iowa	352	426	415	469	588	448	6898
Spokane, Washington	331	469	515	483	561	707	6355
Springfield, Illinois	228	276	282	258	358	282	5373
Springfield, Missouri	193	297	217	222	381	217	4428
Syracuse, New York	484	506	425	619	715	521	6893
Tacoma, Washington	286	358	400	413	487	607	5181**
Terre Haute, Indiana	272	272	233	307	377	233	4872
Toledo, Ohio	420	437	369	523	631	378	6077
Topeka, Kansas	149	284	236	175	328	236	4969
Trenton, New Jersey	323	350	242	372	438	242	4933
Utica, New York	554	512	430	705	737	612	6796
Valentine, Nebraska	420	429	490	564	595	583	7039
Walla Walla, Washington	185	351	332	250	364	362	4808
Washington, D. C.	280	278	251	304	342	251	4626
Wichita, Kansas	143	237	192	173	255	192	4673
Williston, North Dakota	441	480	660	682	742	930	9323
Winnemucca, Nevada	336	437	507	502	465	699	6427**
Yakima, Washington	191	413	437	270	431	557	5599

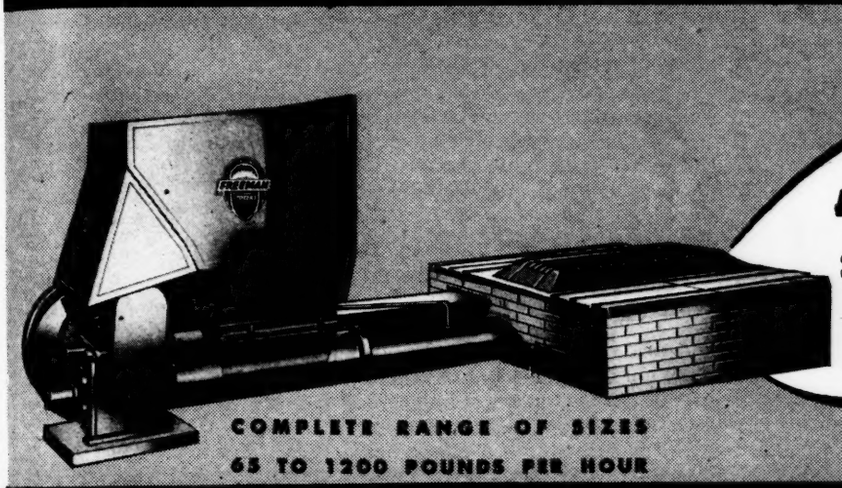
*Includes August. **Includes July and August. (a) Data not available.

[1]Cumulative data identical with monthly figures for September only. In subsequent months, cumulative figures will show record for whole heating season to and including month in question.

[2]Figures in this column are normal totals for a complete heating season, September to June, incl.

FREEMAN STOKERS

FIRST CHOICE OF AMERICA'S FOREMOST HEATING ENGINEERS



A PIONEER OF THE STOKER INDUSTRY... ONE OF THE LEADERS IN NATIONAL SALES VOLUME...

COMPLETE RANGE OF SIZES
65 TO 1200 POUNDS PER HOUR

FREEMAN STOKER DIVISION, ILLINOIS IRON & BOLT CO., 918 SO. MICHIGAN AVE., CHICAGO 5, ILL.

POWERS TEMPERATURE and HUMIDITY CONTROL

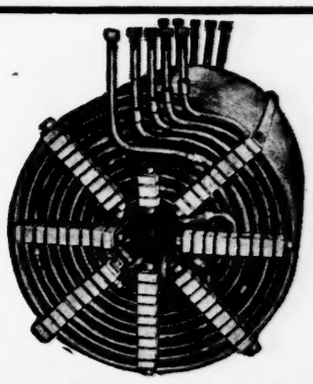
When you want accurate and dependable automatic temperature or humidity control for Heating, Ventilating and Air Conditioning Systems or Industrial Processes call in a Powers engineer. With a very complete line of self-operating and compressed air operated controls we are well equipped to fill your requirements.

THE POWERS REGULATOR CO.
2718 Greenview Avenue CHICAGO

Offices in 47 Cities—See your phone directory

★ Over 50 Years ★
of Temperature and Humidity Control

INTO THIS COIL ➡ WE BENT



half a mile of COPPER TUBING

Here's a job typical of Swan's skill in precision pipe and tube bending. A certain naval condenser unit takes a lot of copper tubing—two tons of it! *Half a mile of it!* To be bent into a coil no bigger than a small clothes closet. Thermal requirements for maximum efficiency of the unit make necessary the placement of the coil surfaces with great precision in all three dimensions.

Swan Engineering did it!
And in quantity!
And on time!

Use our advisory engineering service in connection with your bending problems. Swan Engineering will quote promptly on bending jobs large or small, simple or complicated, in any of the usual metals or alloys including stainless steel and aluminum. *Send your bending to Swan!*

SWAN ENGINEERING COMPANY, Inc.
747 Frelinghuysen Ave. Newark 5, N. J.

. . . Since the Last Issue

Surface Combustion has purchased the building adjacent to its Columbus, Ohio, factory in preparation for substantial increases in post-war employment and production on Janitrol heating equipment. The newly-acquired building adds 130,000 square feet, doubling production space of the Columbus factory. The building purchased is the former Lamneck Products, Inc., factory, a 4-story structure, which will be altered and connected with the present factory at 400 Dublin Avenue by enclosing the connecting areaway.

Alco Valve Company, St. Louis, has made two appointments: **Arley L. Baker** to the post of application engineer, and **Hugo C. Smith** as field engineer.

A. L. Baker

H. C. Smith

Mr. Baker comes to Alco from Curtis Manufacturing Company where, from 1939 until 1944, he held the position of district representative for the north central territory.

Mr. Smith is familiar with the refrigeration field, having spent ten years with Frigidaire Sales Co. and five with the Carrier Corp. The latter connection was terminated by the war. His previous experience has been in the Cleveland area. His territory, with headquarters at Cleveland, will include Ohio, West Virginia and the western part of Pennsylvania.

Allen R. Cobb, vice-president of the **Irving Trust Company** of New York has been elected to the board of directors of **Ross Industries Corporation,** New Brunswick, N. J., whose fully-owned subsidiaries are the J. O. Ross Engineering Corporation and Ross Engineering of Canada Ltd.

Young Radiator Co., Racine, Wis., announces the appointment of the **Rodgers Engineering Company,** Dallas, Tex., as sales and engineering representatives in northeast and north-central Texas.

The Happy Company, Tulsa, Okla., with branch offices throughout the Texas, Mid-Continental and Illinois oil fields, will continue to distribute Young products for producing, refining and pipe line application.

Dresser Industries, Inc., will move its headquarters from Bradford, Pa., to Cleveland, O. Executive offices will be located there in the Terminal Tower. Cleveland already is the home of a Dresser Industries' member company, The Bryant Heater Co., and of an affiliate, Van der Horst Corp. of America. Dresser Industries, Inc. is the parent corporation of a group now comprising 10 companies, all in related lines of manufacture.

Duo-Therm oil heating appliances will be handled in almost all countries abroad by **RCA Victor** distributors and subsidiary companies under a post-war agreement jointly announced by M. F. Cotes, vice-president of the Duo-Therm organization, and Jay D. Cook, managing director of the International Department, RCA Victor Division, Radio Corporation of America.

George E. Simons has been appointed manager of advertising and sales promotion for **General Electric's** air conditioning and commercial refrigeration divisions. Prior to his new appointment, which became effective October 16, Mr. Simons was advertising manager of the General Electric X-Ray Corporation in Chicago. He attended the University of Michigan and joined G-E's publicity department at Schenectady in 1930. That same year he was transferred to the Chicago office of the company as district publicity representative. In 1935 he was named advertising manager of the G-E X-Ray Corporation.

G. E. Simons

Frank O. Zimmerman, Oak Park, Illinois, has been appointed assistant manager of the Chicago sales branch, **Federal Telephone and Radio Corp.** Mr. Zimmerman formerly was with Westinghouse Electric Elevator Company at Chicago and Indianapolis. A graduate of Illinois Institute, he holds high honors in electrical and control engineering.

The **Watson-Stillman Company,** Roselle, N. J. has appointed **John Thomas Gillespie, Jr.,** manager of export sales. During the past 2½ years, Mr. Gillespie has been with the shipbuilding division of WPB as chief of staff branch, and previously with the OPM contract distribution division as chief, liaison section with U. S. Maritime Commission, on a leave of absence from Air Reduction Company, Inc., New York City.

C. Ray Davisson succeeded Joseph F. Wilber as **Chief of the WPB Plumbing and Heating Division** on November 2. He joined the War Production Board staff in January, 1943, as chief industrial advisor to the Office of Industry Advisory Committees. While in that capacity he supervised industry advisory committee meetings for the Plumbing and Heating division and other WPB divisions.

For five years prior to joining WPB, Mr. Davisson was with the Carrier Corporation, Syracuse, N. Y. He was graduated from Ohio State University in 1926 with a degree in business administration, and was with Gulf Oil, Sears-Roebuck and Goodrich before joining the Carrier staff. Before his appointment to the Plumbing and Heating Division, he was serving WPB on a loan basis.

J. Donald Smith

J. Donald Smith, manager of the sales promotion department of the **York Corporation** has been appointed advertising manager. In his new job, Mr. Smith will have charge of all sales promotion, publicity and advertising activities of York refrigeration and air conditioning. Mr. Smith has been with York for nearly 20 years. He began work in the company's erecting department and later was assigned to the architectural and construction division of the engineering department. In 1930, he helped in the organization of York's equipment and supplies department which embraced the publicity and sales promotion activities of the corporation. From then to 1942, Mr. Smith was assistant manager of this department, leaving it in that year to aid the management in the production of vital army ordnance. He returned to promotion work again in 1943 and became manager of the sales promotion department.

(Continued on page 110)

X-PANDO
SEALS THE JOINTS SAVES THE PIPE— *Permanently*

Because X-PANDO PIPE COMPOUND is the only compound that expands as it sets . . . because it comes in one formula for all uses—an absolute, all-purpose pipe compound that does magic even in unskilled hands—it is the standard compound in American Shipbuilding and Industry. Here is permanent leak-proof insurance—a compound that corrects imperfections in threads and smooths flange faces.

Does more . . . less Cost . . . Always!

Economical, goes 6 times further—holds anything carried in metal pipe except certain heavy acids—expands and contracts with pipe movement—joints easily taken apart—withstands deflection, sharp temperature changes, vibration and pressures—better than litharge and glycerine for all uses. X-Pando is more than just a pipe joint compound. It is an all-purpose industrial sealing agent.

★

Used by U. S. Navy, U. S. Maritime Commission, U. S. Coast Guard, U. S. Army, U. S. Army Air Corps, and thousands of Industrial Plants and Contractors.

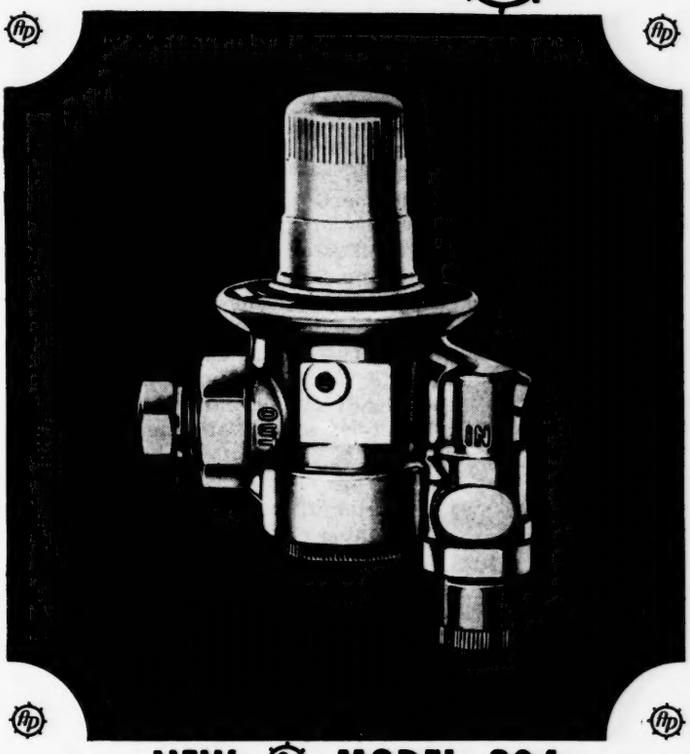
X-PANDO CORPORATION

43-15 36th STREET · LONG ISLAND CITY, N. Y. · STillwell 4-7180

DISTRIBUTORS EVERYWHERE

Dependability doesn't happen . . .

IT'S *BUILT INTO* EVERY A-P VALVE



NEW A-P MODEL 204 AUTOMATIC EXPANSION VALVE

A new design of a famous and popular A-P Valve, the new A-P Model 204 AUTOMATIC Expansion Valve has many new features for improved operation on domestic refrigerators, beverage coolers, serum cabinets, and similar applications. One of these new features is the moisture-proof metal cap, providing absolutely tight seal against air and moisture for protection against freeze-up in the head, yet offering ready access to the adjusting knob.

Compact, small in size, precision-built throughout, sturdy, sensitive and leakproof, Model 204 has an adjustable range of from 15" vacuum to 35 lbs. pressure. Rated at ¼ ton Freon and ½ ton Methyl Chloride and Sulphur Dioxide, it is designed for long-life, dependable service. For further details, write for Bulletin No. 407A.

AUTOMATIC PRODUCTS COMPANY

2462 North Thirty-Second Street • Milwaukee 10, Wisconsin

Export Dept.—13 E. 40th St., New York 16, N. Y.

DEPENDABLE
REFRIGERANT VALVES

Stocked and sold by progressive refrigeration jobbers everywhere . . .
Recommended and installed by leading refrigeration service engineers

(Continued from page 108)

Dario de la Garza, long identified with foreign advertising and sales promotion, has joined the **Carrier International Division** as advertising manager. Former member of Colgate-Palmolive-Peet Company's foreign advertising department, Mr. de la Garza also served for eight years as foreign advertising and sales promotion manager of Servel, Inc. More recently he has been identified with the National Export Advertising Service of New York.

Winkler stoker district sales managers, whose territories blanket the nation, were called to the home offices of the **U. S. Machine Corporation,** Lebanon, Ind., in October for a preview of the company's postwar stoker plans. Improvements on bituminous models, a new anthracite stoker line, and removal of WPB restrictions on stoker sales were discussed by **Herman E. Winkler,** executive vice-president, and **Claude A. Potts,** vice-president and secretary. The sales representatives inspected the company's three Lebanon plants. The most extensive national advertising campaign ever undertaken by the company is a part of immediate and postwar plans.

J. E. Wilhelm

Lester T. Avery, president of the **Avery Engineering Company,** Cleveland, has announced the election of **Joseph E. Wilhelm** as vice-president. The Company celebrated its fifteenth anniversary November 11. Mr. Wilhelm has served as chief engineer of the Company and will continue these duties. He is a registered Ohio professional engineer and a graduate of Case School of Applied Science, Cleveland.

Oscar M. Havekotte, Columbus, Ohio, has been elected a director of **Dresser Industries, Inc.** Mr. Havekotte, for the past four years president of International-Stacey Corporation and of International Derrick and Equipment Company, both Columbus concerns, will continue as head of the latter company. Dresser Industries on Nov. 1 acquired the assets of International-Stacey Corporation, which will be dissolved, and of its subsidiaries, which will continue in operation. The acquisition gives Dresser Industries, Inc., a leading position among manufacturers of equipment for the oil, gas and water fields. The 10 companies now comprising the Dresser group manufacture a rounded line of products, from pipe couplings to large pumps, blowers and compressors. They include derricks, drilling apparatus, radio and airport towers and equipment, gas storage tanks and gas-fired home heating equipment.

As International-Stacey winds up its corporate affairs, its factories and those of its subsidiary companies will continue in full operation, without change of local managements. International Derrick & Equipment Co., Roots-Connersville Blower Corp. and Stacey Bros. Gas Construction Co. become new units in the Dresser group, each continuing to operate under its own name.

Large-scale expansion of its oil well supply business is being undertaken by the **Buffalo Bolt Co.,** North Tonawanda, N. Y., Rudolph B. Flershem, president, disclosed Nov. 30 in announcing the conclusion of negotiations for the purchase of the entire capital stock of the S. M. Jones Co., Toledo, O., maker of sucker, pony and pull rods and accessories.

W. A. Smith has been appointed manager of suspension sales by **The B. F. Goodrich Company,** Akron, Ohio.

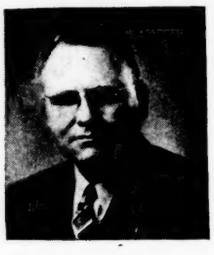
Donald G. Cameron, electrical engineer, has been appointed recently to head the engineering department of **Penn Electric Switch Co.,** Goshen, Ind. Mr. Cameron was associated for 15 years with General Electric Co., and in recent years was superintendent of that company's aircraft instrument division at West Lynn, Mass. In his capacity of chief engineer, Mr. Cameron will be directly in charge of all engineering work on Penn's products.

D. G. Cameron

Bailey Meter Company, Cleveland, Ohio, has appointed **P. S. Dickey** as chief engineer. Mr. Dickey will supervise all engineering, research and design activities for the Company. He will be assisted by H. H. Gorrie, assistant chief engineer, and R. E. Clark, manager of contract engineering. In his former position of research engineer, Mr. Dickey has conducted numerous studies here and abroad on the problems involved in the control of both forced and natural circulation boilers in stationary, marine, and mobile service. He is a mechanical engineering graduate of Purdue University and has served Bailey Meter Company continuously in various engineering capacities since his graduation in 1925. Mr. Gorrie is a graduate of Rensselaer Polytechnic Institute and has been associated with Bailey continuously since 1927. Mr. Clark, a graduate of the University of Kentucky, has completed over 20 years service with the Company.

C. M. Baumgardner has been appointed general manager of sales of **United States Radiator Corporation,** with headquarters in the general offices, Detroit, to fill the vacancy caused by the resignation of R. P. Henderson. Mr. Baumgardner has for the past fifteen years been manager of the Chicago branch with jurisdiction over sections of Michigan, Indiana, Illinois and Iowa. He is succeeded in Chicago by S. Wolpert, formerly assistant branch manager. A. X. Bergeron has assumed the duties of assistant branch manager.

Allen K. Snyder has recently rejoined **Carrier Corporation,** Syracuse, N. Y., as staff assistant to Les M. Beals, director of advertising and sales promotion. Mr. Snyder returns to the air conditioning and refrigeration industry from a five year association with Dayton Rubber. Prior to that, he was advertising manager for Chrysler Airtemp.

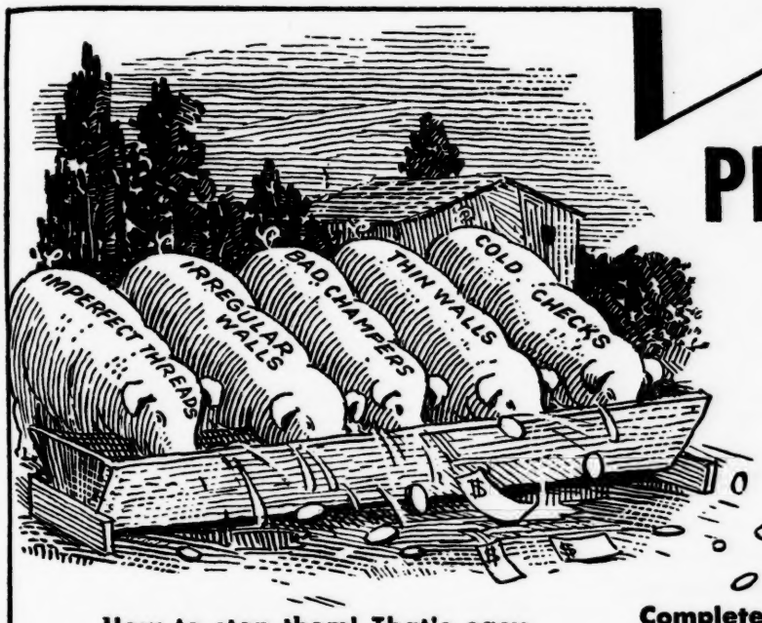


J. A. McDaniel

Schwitzer-Cummins Co., Indianapolis, has appointed **James A. McDaniel** as sales manager of its Heating Division. He has been actively engaged in the field in the establishment of new distributors and in working among key dealers. Many of Mr. McDaniel's years in the industry were in sales promotion work both in the East and West, and cover anthracite and bituminous burning equipment.

Paul Ryan, former president of the National Refining Company of Cleveland, Ohio, who recently has been serving with the Petroleum Industry War Council, has been elected a vice-president of **The M. W. Kellogg Company,** petroleum and chemical engineers, Jersey City, N. J., and New York. Mr. Ryan will manage a newly instituted consulting service which is expected to prove of great value to oil refiners in the post-war era.

(Continued on page 112)



FIVE LITTLE PIGS *at the Profit Trough*

Here they are . . . cold checks, thin walls, irregular walls, imperfect threads, bad chamfers . . . each and every one of them eternally eating profits because of call-backs.

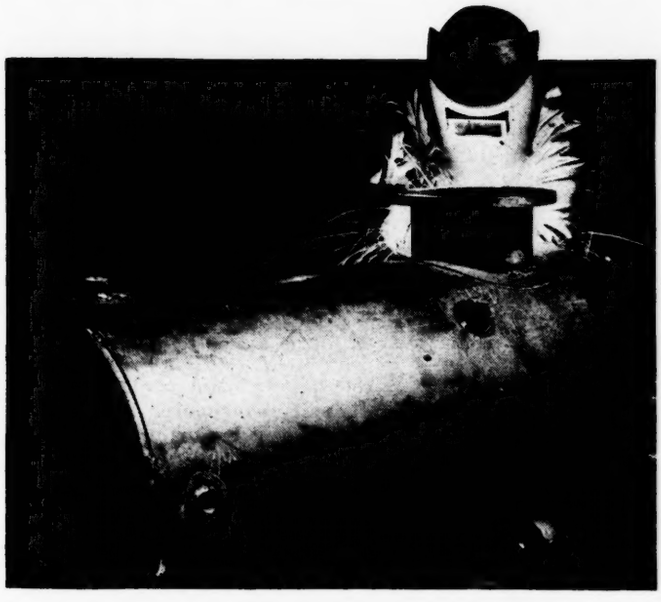
How to stop them! That's easy. Confine your fitting sources to responsible jobbers and you'll be supplied perfect fittings only.

"K" fittings are precision built, thoroughly inspected, and in stock at responsible jobbing houses exclusively.

Complete Line. Catalog on Request.
Standard and extra heavy cast-iron screwed fittings.
Standard flanged fittings.
Standard and extra heavy companion flanges.
Drainage fittings.

"K" fittings are carried in stock at Malleable Iron Fitting Co., Branford, Conn.; M. I. F. stocks at Kuhns Bros. Co., Dayton, Ohio.

KUHNS BROTHERS CO.
DAYTON 7, OHIO



ADSCO HEATERS
Are built to your order

— Horizontal or Vertical, Storage or Instantaneous Heat Economizers and Special Equipment. Submit the details of your heating or cooling problems to us or write for bulletin No. 35-75HV.

AMERICAN DISTRICT STEAM COMPANY
NORTH TONAWANDA, N. Y.

Obsoletes Riveted, Bolted Construction

NOW YOU CAN WELD GALVANIZED IRON AND STEEL

sheets, shapes and pipe and leave all surfaces

100% RUST and CORROSION PROOF

by regalvanizing the seams and joints with the

GALV-WELD PROCESS

- Easy to use
- Fast
- Permanent
- No Flux Required
- No Fumes
- No Sandblasting
- Cannot be pried or peeled off.
- Applied in any position and in confined quarters.
- Economical.

Production-proved in wartime service by the shipbuilding industry. Galv-Weld Alloy (Reg. Trademark) is equal to and/or better than hot dip galvanizing in corrosion resistance. The bond to the base metal is superior to zinc metal spray. Has withstood all government tests.

Especially applicable in the case of sheet metal ducts and refrigeration units.

GALV-WELD PRODUCTS
314 W. 1st St., Dayton, Ohio

Please send, without obligation, information on the Galv-Weld Process and sample of Galv-Weld Alloy.

Name.....
Firm.....
Street.....
City.....

(Continued from page 110)

S. R. Edwards

Yarnall-Waring Company, Philadelphia, has appointed **S. R. Edwards** in charge of the company's new southwestern sales office at 805 Texas Bank Bldg., Dallas, Tex. Mr. Edwards, a graduate of Purdue University in mechanical engineering, has had fifteen years experience in sales and engineering work.

N. Stuart Irwin has been appointed assistant director of advertising and sales promotion for the **Carrier Corporation,** Syracuse, N. Y. For the past six years Mr. Irwin has been with General Electric and Sherwin-Williams, engaged in advertising, promotion, and management-employee relations.

At a recent meeting of the board of directors, **Kenneth McCreary** was elected president of the **Goetze Gasket & Packing Co., Inc.,** New Brunswick, N. J. He has been associated with this company since 1932 and has served consecutively as assistant to the president, treasurer and vice-president and treasurer. He succeeds Frederick Goetze, who died January 30.

Eric Bergman, engineer with the **Petroleum Administration for War,** New York City, has resigned effective December 1, and will return to his former field. He has specialized in the design and establishment of degree day systems.

Employes of **The Hotstream Heater Co.,** Cleveland, Ohio, were feted at a dinner party to mark the formal opening of the company's new plant at 2363 East 69th St. Plant capacity has been nearly doubled. During normal times, about 200 persons are employed.

John H. Read

John H. Read has been appointed as advertising and sales promotion manager of **Williams Oil-O-Matic Corp.** He comes to Williams from the United States Treasury Department where, for the last three years, he was regional manager of the War Finance Committee of Illinois in charge of war bond sales in downstate Illinois. Prior to his Treasury Department appointment, Mr. Read was with the Mace Advertising Agency, Peoria, Illinois, as Account Executive. He also spent seven years with Shell Oil Company, New York, in their advertising and promotional departments, and for four years of this time had been Assistant Sales Manager of the Shellane Division (liquified petroleum gas) in which capacity he handled merchandising and advertising of gas burning appliances.

Devenco Incorporated, 150 Broadway, New York, N. Y., an organization of specialized consulting technicians, has acquired additional engineering department facilities at 73 Warren Street, New York, to meet its expanding requirements.

R. W. Davis has been appointed general manager of the **Allis-Chalmers Mfg. Co.'s,** Norwood, Ohio, works. The Norwood plant is engaged principally in the production of electrical equipment and centrifugal pumps in the smaller sizes of the company's line.

Walter W. Mohr, 48, a member of the engineering staff of **The Edward Valve & Mfg. Co., Inc.,** East Chicago, Ind., for 24 years, and its chief engineer for 16 years, died November 13 at St. Margaret's Hospital in Hammond, Ind., after an illness of several weeks. He was the inventor of many types of valves, valve operating mechanisms and valve design improvements.

Born in Hanover, Germany, he came to this country as a young man and made his home in Sheboygan, Wis. Six years later he came to the Calumet area and after a few months with a Chicago engineering firm, he joined the Edward company. He is survived by his widow, a daughter, and a son.

Allen Swartzmiller has been appointed manager of the Furnace Division of **Jackson & Church Co.,** Saginaw, Mich. Mr. Swartzmiller comes to Jackson & Church after a two-year absence from the heating field, during which he served in an administrative capacity of a large plant turning out machine guns for the armed services. His wide experience in the heating and heating accessory field includes several years service as Michigan state distributor of numerous heating products.

Roger Tewksbury, president of **The Oster Mfg. Co.,** Cleveland, Ohio, announces the appointment of two new

L. D. Martin *T. S. Bonnema*

officers at a meeting of the Board of Directors October 27: **Theodore S. Bonnema,** formerly production manager, now becomes vice-president in charge of production and **Lester D. Martin,** formerly comptroller, is made treasurer of the company. Both men have seen more than twenty years service with the company in various capacities. Other company officers, remaining in their present capacities, are **Arthur S. Gould,** senior vice-president in charge of sales, and **Harry A. Maurer,** secretary.

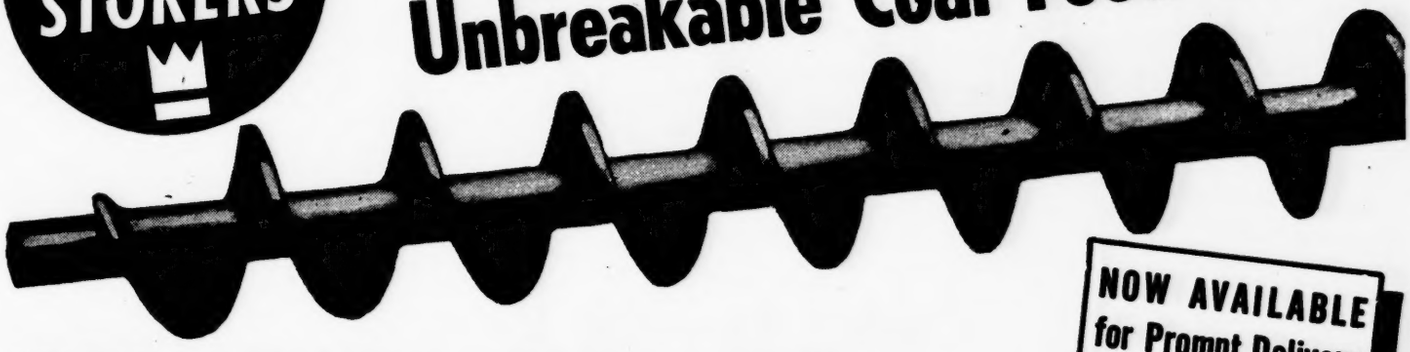
West Virginia Coal & Coke Corporation held a sales conference at the general offices of the company in Cincinnati October 26-27. Those attending inspected the mines of the company in its Logan Division at Omar, W. Va. Since 1939 West Virginia Coal & Coke Corporation has been modernizing its mines through a large mechanization and development program, which program will be completed by the beginning of 1946, at which time all of its Island Creek seam coals will be mechanically mined. The salesmen inspected the multi-million dollar central cleaning plant construction project now under way which, after completion, probably by the summer of 1945, will have a capacity of ten thousand tons per day. This new cleaning plant will serve as the tipple and cleaning plant for all of the company's Island Creek seam mines except No. 5 mine. They also inspected the completed tipple and cleaning plant at No. 5 mine. This new mine development program has already stepped up the production of the Corporation's mines from 2,437,476 tons in 1939 to 4,061,600 tons for 1944 (based on ten months' production) or an increase of 67% above the pre-war year of 1939. This compares with a national increase of 52% for the same period.

A. C. Palm has been appointed advertising and sales promotion manager of **The Tremco Mfg. Co.,** Cleveland, and The Tremco Mfg. Co. (Canada) Ltd., Toronto.

(Continued on page 114)

For STOKERS

The CROWN Unbreakable Coal Feed Screw



NOW AVAILABLE for Prompt Delivery

WELDED All-Steel Worm—All Sizes—All Pitches

★For replacement or production needs, Crown is now able to offer for prompt delivery its all-steel Coal Feed Screw. Available with right or left hand screw, in all sizes and pitches, tapered or straight, and in combinations of pitches. For both domestic and industrial stokers, the Crown Coal Feed Screw insures longer and continuous operation because it is all-steel and because it is machined so smoothly that wear is reduced to a minimum. This smooth surface is your assurance, too, that coal will flow freely and easily through the flights. Prompt delivery is possible because production requires less time on Crown's automatic machines and because the steel used in Crown's Coal Feed Screw while critical, is more easily procured.

In ordering give complete specifications on size and design.

CROWN IRON WORKS COMPANY

1229 Tyler St., N. E. *Since 1878* Minneapolis, Minn.

Just use it once—

The Alnor Velometer

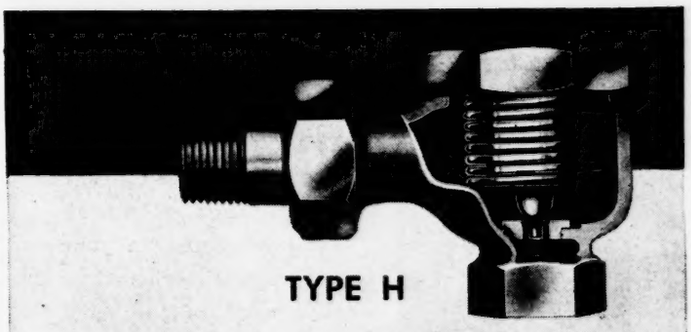
gives you instantaneous, direct readings of air velocity in feet per minute. Hold it in the air stream for low range readings; use the tube-connected special jets for high range readings or inaccessible locations. That's all there is to it, and once you use the Alnor Velometer you will never tolerate other methods.

The Alnor Velometer is built in several standard ranges from 20 fpm to 6,000 fpm, and up to 3 inches static or total pressure. Special ranges available as low as 10 fpm, and up to 25,000 fpm and 20 inches pressure. Write for Velometer bulletin.

ILLINOIS TESTING LABORATORIES, INC.

420 NORTH LA SALLE STREET

CHICAGO 10, ILLINOIS



TYPE H

One in a Million

A good radiator trap removes air and condensate from radiators rapidly and without noise or fuss, day after day—for the life of the system, and with negligible replacement cost.

Sarco has been building such quality heating specialties for nearly thirty years. For all that time, an outstanding and exclusive feature has been the Sarco heavy-wall bellows, drawn from flat blanks in our own plant, and helically corrugated.

It costs us more, but we are amply compensated by customer satisfaction resulting from trouble-free service and unusually long life. Ask for Catalog No. 160.

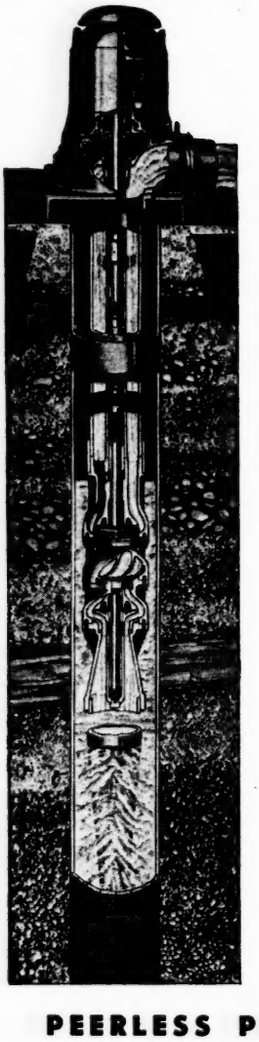
SARCO SAVES STEAM

SARCO COMPANY, INC.
475 Fifth Avenue, New York 17, N. Y.
SARCO CANADA LTD 85 Richmond St W TORONTO ONT

184

PUMPING WATER
"the economical way"
With Peerless Turbine Pumps

The indisputable *economy of operation*, that is peculiarly a *Peerless feature*, is not just a happenstance. The ingenuity of top-notch engineers, the unusual skill of precision-minded, highly-trained pump building mechanics working with *better materials*, plus years of painstaking laboratory and field tests alone were the factors responsible for not only the marked economy, higher sustained efficiency and greater dependability of every Peerless pump, but also the fact that Peerless products are from the factories of the world's largest manufacturer of deep well Turbine pumps.



ARMY NAVY
PEERLESS PUMPS

Experienced Pump Engineers to assist you

The Peerless Pump Distribution Organization, a member of which will be found in your near neighborhood, is composed of the most efficient and dependable pump men in the country today. Cooperating with our own factory-trained field engineers, they stand ready to offer you of their wide experience and skill.

PEERLESS PUMP DIVISION
FOOD MACHINERY CORPORATION

301 W. Ave. 26, Los Angeles 31, Calif. • 1250 Camden Avenue S. W., Canton 6, Ohio • Other Factories: San Jose 5, Fresno 16, California.

PEERLESS PUMPS
TURBINE — HI-LIFT — HYDRO-FOIL

(Continued from page 112)

R. H. Lewis

New officers of the **Ruud Manufacturing Company**, Pittsburgh, Pa., are **R. H. Lewis**, president and general manager, succeeding **A. P. Brill**, who has been made chairman of the board, **J. H. Sorg**, vice-president and counsel, **M. M. Scott**, vice-president in charge of sales and advertising, **K. M. Clark**, secretary and treasurer, and **J. K. Roth**, assistant secretary and assistant treasurer.

Members of the new board of directors are A. P. Brill, chairman; R. H. Lewis, J. H. Sorg, K. M. Clark, M M. Scott, M. G. Hulme, W. W. McVay, W. R. Daley and M. W. Taylor.

The company, reports president R. H. Lewis, has completed all its war contracts and has reconverted its Kalamazoo, Mich., and Toronto, Ont., plants to the manufacture of gas water heaters within the limits imposed by WPB and with future expansion of production dependent on WPB rules and restrictions.

Walter Dorwin Teague, New York, industrial designer, has announced the addition of **Walter A. Bowe** to his staff as an associate in industrial planning and consultant on the sales problems of clients. For the last eight years Mr. Bowe has been advertising and sales promotion manager of Carrier Corporation, Syracuse, N. Y. He recently served as technical advisor to the inaugural sessions of the Carrier Institute of Business, an employee-relations program which has achieved national recognition in industry. Previous to his association with Carrier, Mr. Bowe was with the General Electric Co. in various advertising executive positions. He is a vice-president of the National Industrial Advertisers Association, a professional member of Alpha Delta Sigma, and has been active in the Association of National Advertisers and the public relations activities of the air conditioning and refrigeration industry.

W. R. Stockwell

In honor of his 50 years of service in the radiator heating industry, **W. R. Stockwell**, general manager of the manufacturing division, **Weil-McLain Company**, was presented with a handsome watch by members of **The Institute of Boiler and Radiator Manufacturers** at a cocktail party given by the Institute at its annual meeting at the Westchester Country Club, Rye, New York, during the week of October 9. Mr. Stockwell served for two years as chairman of the Institute. He began his career in the heating industry when he entered the employ of Lord and Burnham, now the Burnham Boiler Corporation, in 1894. He worked for Lord and Burnham for 24 years. For the past 26 years he has been general manager of the manufacturing division of Weil-McLain.

Appointment of **A. J. Schmitz** as Pacific regional manager has been announced by Frank Angle, manager of district offices, **Allis-Chalmers Mfg. Co.** Previous to his appointment, Mr. Schmitz was manager of the Seattle office, and prior to that, manager of the Portland office. He has been with the company since 1914.

A streamlined program for postwar products development and redesign will make possible a reduction as high as 25% in the number of refrigeration and air conditioning items manufactured by the **York Corporation**, York, Pa.

(Continued on page 115)

(Continued from page 114)

Sperry Products, Inc., Hoboken, N. J., announces the recent addition of **J. L. Stuart** to its technical staff. Mr. Stuart, late of Anaconda Copper's consulting engineer's office, will handle, as technical editor, all technical writing relative to the Sperry line of hydraulic remote controls and other Sperry products.

S. M. Rust, retiring president of **The Rust Engineering Co.,** has been elected chairman of the company's board of directors; and **S. M. Rust, Jr.,** who has been serving as executive vice-president, has been elected president of the company, the board of directors announces. Mr. Rust, Jr., entered the organization after graduation from Lehigh University in mechanical engineering, working in the field and in various other capacities before becoming vice-president.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., REQUIRED BY THE ACTS OF CONGRESS OF AUGUST 24, 1912, AND MARCH 3, 1933, OF HEATING AND VENTILATING, published monthly at New York, N. Y., for October 1, 1944.

State of New York, County of New York, ss.:

Before me, a Notary Public in and for the State and County aforesaid, personally appeared Edgar A. Becker, who, having been duly sworn according to law, deposes and says that he is the Treasurer of The Industrial Press, publishers of HEATING AND VENTILATING, and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management, etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, The Industrial Press, 140-148 Lafayette St., New York 13, N. Y.

Editor, Clifford Strock, 140-148 Lafayette St., New York 13, N. Y.

Managing Editor, N. N. Wolpert, 140-148 Lafayette Street, New York 13, N. Y.

Business Managers, Robert B. Luchars, 140-148 Lafayette St., New York 13, N. Y.; Edgar A. Becker, 140-148 Lafayette St., New York 13, N. Y.; Erik Oberg, 140-148 Lafayette St., New York 13, N. Y.

2. That the owners of 1 per cent or more of the total amount of stock are: The Industrial Press, Robert B. Luchars, Edgar A. Becker, Franklin D. Jones, Walter E. Robinson, and Charles O. Herb, all of 148 Lafayette St., New York 13, N. Y.; Helena E. Oberg, 65 Eighty-second St., Brooklyn 9, N. Y.; Wilbert A. Mitchell, 28 Harlow Road, Springfield, Vt.; First National Bank & Trust Co. of Montclair and Robert B. Luchars, Trustees (Beneficiaries unknown), Upper Montclair, N. J.; First National Bank & Trust Co. of Montclair and Leigh Roy Urban, Trustees (Beneficiaries unknown), Upper Montclair, N. J.; First National Bank & Trust Co. of Montclair and Kenneth D. Ketchum, Trustees (Beneficiaries unknown), Upper Montclair, N. J.; Paterson Savings Institution, Trustee (Beneficiaries unknown), Paterson, N. J.

3. That the known bondholders, mortgagees, and other security holders are: Charlotte B. Baldwin, 420 Clinton Ave., Brooklyn, N. Y.; Robert B. Luchars, John Connolly, Franklin D. Jones, and Louis Pelletier, all of 148 Lafayette St., New York 13, N. Y.; Elizabeth Y. Urban, 163 Western Drive, Longmeadow, Mass.; Helen L. Ketchum, 231 King St., Cohasset, Mass.; Wilbert A. Mitchell, 28 Harlow Road, Springfield, Vt., and Henry V. Oberg, 1317 Hillcrest Rd., Lancaster, Pa.

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

EDGAR A. BECKER, Treasurer.

Sworn to and subscribed before me this 21st day of September, 1944.

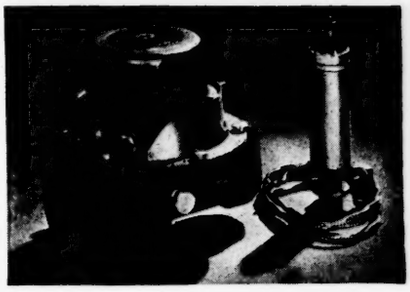
CHARLES P. ABEL.

Notary Public, Kings County No. 292; Kings Register's No. 116-A-5; N. Y. County No. 233; N. Y. Register's No. 153-A-5. My commission expires March 30, 1945.

Uninterrupted Operation

OF GAS-FIRED EQUIPMENT

...independent of outside current supply



B-60
ALL GAS CONTROLS

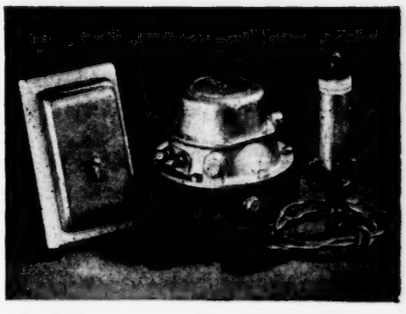
During storms or other emergency shut-offs of outside current, B-60 Automatic Control Systems provide uninterrupted gas heating control. No outside electric current is required because B-60 All-Gas Controls are fully self-operating, all necessary current being supplied by a thermocouple pilot generator. No other valve can match this performance.

The B-60 Valve has set a new standard for the safe, automatic control of fuel supply to gas floor furnaces, gas-fired boilers, radiators, ranges, water heaters, and other gas-fired equipment in homes and industry.

Available in sizes ⅜" to 1½" I.P.S. handling natural, manufactured, liquefied petroleum gases. For complete specifications write for Catalog 52B or call nearest General Controls' factory branch or distributor.

AVAILABLE IN PACKAGE SETS

B-60 All-Gas Controls available in Package Sets which provide everything necessary for remote room temperature control: B-60 Control Valve; thermocouple pilot generator; T-80 Series thermostat (with or without thermometer and 13½ hr. timer); 30 ft. wire.



WRITE FOR CATALOG 52B

GC

what..

GET READY FOR SUMMER now?

yes!

GET IN TOUCH WITH WHITLOCK now

FOR EQUIPMENT AND ENGINEERING SERVICE ON REFRIGERATION

Before you know it Spring will arrive and balmy days will bring refrigeration problems! Now is the time to order necessary repairs and plan improvements to be ready for warm weather. WHITLOCK engineers will gladly work with you to put equipment at peak efficiency for the coming season.

Manufacturing facilities and ample stocks of materials at WHITLOCK insure prompt delivery of vital parts . . . condensers, receivers, welded headers, coils and prefabricated piping.

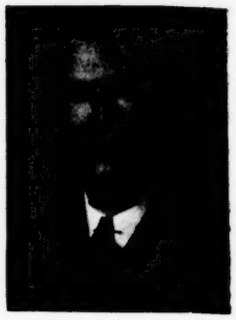
Write to-day for recommendations.

THE WHITLOCK MANUFACTURING CO.

40 South Street, Elmwood, Hartford 1, Conn.

New York · Boston · Chicago · Philadelphia · Detroit · Richmond
Authorized representatives in other principal cities.
In Canada—Darling Brothers, Ltd., Montreal

Getting Personal

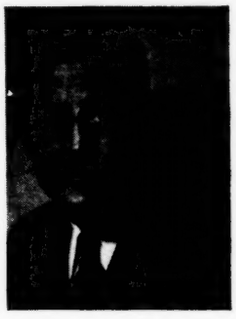


C. O. Mackey

C. O. Mackey (Sol-air Temperature—A New Concept, page 62) was born in Ithaca, N. Y., and received his M.E. degree from Cornell University in 1926.

Since 1924, he has been successively Instructor of Experimental Engineering and Instructor, Assistant Professor, and Professor of Heat-Power Engineering at Cornell. At present, he is in charge of the Mechanical Engineering Laboratory at that university.

Professor Mackey is the author of Air Conditioning Principles (International Textbook Company), Graphical Solutions (John Wiley & Sons), co-author of Thermodynamic Charts (with F. O. Ellenwood), and has written many technical articles for HEATING AND VENTILATING and other engineering publications. He is a member of A.S.H.V.E. and A.S.R.E., and is now engaged in a research project on cooling load in summer air conditioning sponsored by the A.S.H.V.E. in cooperation with cornell University.



V. P. Victor

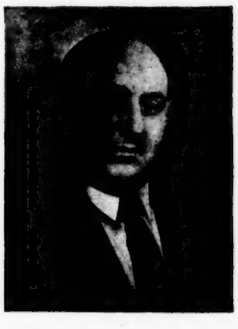
In introducing **V. P. Victor** (V. P. Dolengo-Kozerovsky), we are presenting an engineer who has truly seen much of this world (Solution of Drying Problems, page 67).

Born in Russia, he attended the Naval Academy and saw active service in World War I. After several years of travel in Europe, South America and Africa, he came to the United States.

He completed a 5-year cooperative course at the University of Cincinnati where he received an M.E. degree. Before and during his stay in Cincinnati, he specialized in the operation and design of automatic machinery and machine tools.

For the past 15 years, Mr. Victor has worked on the development, sales and operation of the various industrial air systems, principally in the food and chemical fields. For the last 3½ years he has lectured in New York schools on the subjects of machine design and production engineering. At present, he is consulting engineer with an office in New York City.

While his favorite hobbies are chess and swimming, he is also a water color painter of landscapes. In addition, he brags about his thorough study and intimate acquaintance with all West Indian rums.



Irwin G. Jalonack

Irwin George Jalonack (Radiant Heating Panel Calculations, page 55, was born in Syracuse, N. Y. In 1932 he received a B.S. from Carnegie Institute of Technology, Pittsburgh, where he majored in the fields of plumbing, heating and ventilating.

From 1932 to 1941 he was chief engineer for General Electric Heating and Air Conditioning Distributor—Brooklyn and Long Island. Except for a brief time with Giffels & Vallet as

mechanical engineer at the Norfolk Naval Operating Basin, he has served since 1941 as chief mechanical engineer with Levitt & Sons.

Mr. Jalonack has worked as a journeyman plumber and factory maintenance mechanic, and he has also designed a large number of domestic heating systems.

Despite his 200 pounds, his hobbies include tennis and black bass fishing. At present he is experimenting in his home on radiant cooling applications.

Welding Cast Iron

A 12-page illustrated booklet, "4 Ways to Salvage, Reclaim and Conserve Iron Castings by Electric Arc Welding." Opens with a discussion on inherent difficulties encountered in arc welding cast iron, and points out that there is no single welding material or procedure which can be recommended as a universal practice. It is emphasized that selection of a procedure for a specific application should be based on requirements of the finished job. Four types of electrodes for use on cast iron are described, and characteristics and best welding procedures for each explained.—*C. E. Phillips & Co., 2750 Poplar St., Detroit 8, Mich.*

Clamps

A catalog on Punch-Lok clamps and fittings for many purposes. Feature of the catalog is the pictorial descriptions, accompanied by text of the many clamps and fittings, together with tables giving information on all sizes.—*The B. F. Goodrich Co., Akron, Ohio.*

Fluxes

Catalog 44 describing the complete line of the company's fluxes. Included in the line are 20 fluxes for welding, brazing, silver soldering, soft soldering and low temperature alloy welding of ferrous and non-ferrous metals and alloys.—*Superior Flux Co., 913 Public Square Bldg., Cleveland, Ohio.*

Raybestos Activities

A descriptive booklet, portraying the part Raybestos-Manhattan, Inc. is playing in the War and will play in the post-war era. Included are descriptions and photographs of the many activities of the various plants. Also contained is a history of the various Divisions which form *Raybestos-Manhattan, Inc.* These are: The Raybestos Division, Stratford, Conn.; The Manhattan Rubber Mfg. Division, Passaic and Whippany, N. J. and Neenah, Wis.; United States Asbestos Division, Manheim, Pa.; General Asbestos & Rubber Division, North Charleston, S. C.; The Canadian Raybestos Company, Ltd., Peterborough, Ontario, Canada, and Raybestos-Belaco, Ltd., London, England.

Welding Electrodes

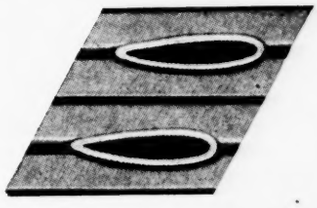
Bulletin L6348 on arc welding electrodes, gives a description of each electrode in the company's line, and includes separate charts on physical properties of weld metal for each electrode as well as on recommended current values.—*Allis-Chalmers Mfg. Co., Milwaukee 1, Wis.*

Republic's War Record

The "service record" of Republic Steel Corporation in World War II is given in a hundred-page book just released by the company, entitled "Republic Goes to War."

Announcing Series 15

UNIT HEATERS



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Streamline

COPPER

TUBES AND FINS

Every man who specifies, sells, installs and uses unit heaters should know about the combined air handling and heat transfer efficiency of Fedders new Series 15 Models.

In addition, they provide extreme ruggedness resulting from advanced wartime metal brazing and fabricating skills.

Send for new Catalog 15C-1 just off press.

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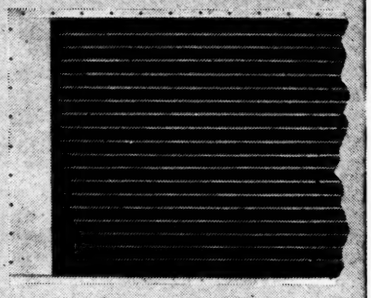
McCORD
HEATING AND AIR CONDITIONING PRODUCTS

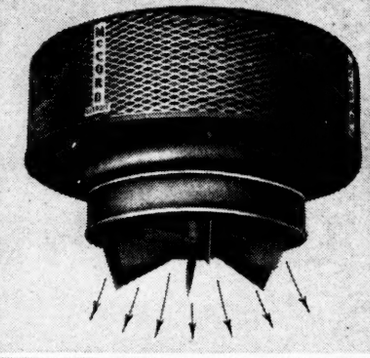
BLAST HEATING COILS
AIR CONDITIONING COILS
ALL TYPES

McCord spiral fin tube construction with the tubes formed or bent permits uniform expansion without strain. Headers are heavy wall construction with tubes brazed into extended ferrules formed in the headers. Fins are helically wound and metallically bonded.



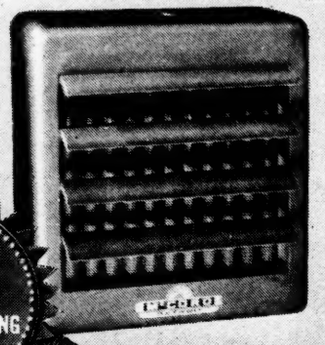
VERTICAL TYPE
UNIT HEATERS

A tried and proven heating unit, modern in design. McCord spiral fin tube construction creates air turbulence without undue restriction, thus increasing heat transfer capacity. Guaranteed for 150 lbs. saturated steam pressure. Nine models.



HORIZONTAL TYPE
UNIT HEATERS

Proven, rugged, modern design. Quiet, guaranteed for use on #150 p.s.i. steam pressure. Heating element, individual spiral fin tubes free to expand without strain on joints. Standard motors with standard bases used. Ten models.



YOU CAN DEPEND ON McCORD AIR CONDITIONING PRODUCTS

McCord RADIATOR & MFG. CO.
DETROIT II, MICH.

(Continued from page 117)

Instruments

A 28-page general catalog issue of "Modern Precision" Folder ENT (7a) describing instruments for measuring by each of the company's four pyrometric methods: thermocouple, Rayotube, Thermohn and optical. For other plant processes, equipments which measure such quantities as pH, speed, gas analysis, etc., are described. A large chart shows the particular instrument model which is available in each case, while installation photographs show equipments in service. Another section is devoted to discussion of heat-treating furnaces, with a page describing and illustrating each method. Another section covers laboratory instruments.—*Leeds & Northrup Company, 4934 Stenton Avenue, Philadelphia 44, Pa.*

Metal Hose

An 8¼ x 3¾ in., 12-page pamphlet entitled Flexible Metal Hose for Every Industrial Use and describing, illustrating and giving data on the company's Rex-Tube flexible metal hose, Rex-Weld corrugated flexible metal hose, Rex-Tite heatproof mechanical couplings, C.M.H. stainless steel bellows and other types of flexible metal hose and fittings.—*Chicago Metal Hose Corp., Maywood, Ill.*

Cooling Towers

A standard size, 20-page catalog No. 145, in three colors, containing in attractive form information on the company's line of water cooling towers. Includes data on scope of designs and constructions, operating principles, and engineering considerations, together with drawings and photographs.—*C. H. Wheeler Mfg. Co., Lehigh & Sedgley Aves., Philadelphia 32, Pa.*

Air Recovery

Air Conservation Engineering, a 120-page book offers a comprehensive and timely treatise on the principles and application of air recovery. Air conservation is defined as the purification and recovery of used air in the interest of economy in air conditioning. Nature of air-entrained impurities—dust, smoke, fumes, vapors and gases—and their elimination are dealt with extensively. The principle of sorption and its application are presented in non-technical language. Value of air recovery for protection against contaminated air intakes, for abatement of polluted exhaust air nuisances, and for control of air purity in connection with industrial hygiene as well as in food, medicinal and other processing operations, is explained and illustrated by numerous typical examples.—*W. B. Connor Engineering Corp., 114 E. 32nd St., New York 16, N. Y.*

Filters

A four-page standard size bulletin entitled "Far-Air Filters", which describes and illustrates the company's air filter in various designs for numerous applications, including marine, railroad, aviation, small engine, diesel engine assembly, round and automatic cleaning rotary types. Bulletin contains technical information and graphs.—*Farr Co., 2615 Southwest Drive, Los Angeles 43, Calif.*

Explosive Rivets

A standard size, 10-page bulletin entitled "High Speed Blind Riveting with DuPont Explosive Rivets," which are installed in two easy steps. First, riveter inserts them in holes and, second, he applies heated riveting iron to each head for 1½ to 2 seconds and rivet is set. Bulletin includes information enabling user to determine type of application where rivet is suitable, together with tabular data on size, strength and other information regarding the riveting itself.—*E. I. du Pont De Nemours & Co., Inc., Wilmington 98, Delaware.*

(Continued on page 119)

(Continued from page 118)

Air Conditioning

How to plan post-war air conditioning to control temperature and humidity, clean the air, and provide adequate ventilation and air circulation is discussed in this 16-page illustrated booklet. It tells how air conditioning works, outlines the principal factors which must be considered to plan air conditioning for a specific application, and pictures and describes equipment including compressors, condensers, units and coils. Installation photos illustrate the three general types of air conditioning—self-contained, factory-built within-the-space units, self-contained factory-built central-plant units, and custom-built central-plant units. — *Westinghouse Elevator Company, 150 Pacific Avenue, Jersey City 4, N. J.*

Presses

Bulletin 130A describing hydraulic equipment for the process industries. It covers a comprehensive line of hydraulic presses, pumps, and accumulators, as well as forged steel fittings and valves. The hydraulic presses described and illustrated cover an unusually wide range. The section on hydraulic pumps covers vertical, single, two plunger and triplex types; two, four and multi-plunger horizontal pumps, as well as single and double plunger pumps to meet all requirements in the process industries. Also described are Watson-Stillman accumulators, intensifiers, hydraulic gauges, valves and forged steel fittings.—*The Watson-Stillman Co., Roselle, N. J.*

Cold-Rolled Paintgrip

A 12-page, standard size bulletin entitled "Armco Cold-Rolled Paintgrip—Where and How to Use It." Publication is a technical one containing descriptive information including the physical properties of the product, its resistance to corrosion, paint life, how to specify it, forming ability, grades in which available, and information on welding it, cleaning and finishing the sheets. —*The American Rolling Mill Co., 703 Curtis St., Middletown, Ohio.*

Industrial Stokers

Bulletin No. 202 of 12 pages presents data and photographs of installations of the Lo-Set Ramfeed Stoker designed for medium sized industrial boilers such as are found in laundries, dairies, schools, commercial buildings, hospitals and hotels. Bulletin No. 203, of 12 pages, describes the Vulcan Heavy Duty Ramfeed Stoker for large industrial applications such as power generation, process work, drying ovens, evaporators and central heating systems.—*Canton Stoker Corp., 500 Andrew Place S.W., Canton, Ohio.*

Fans

A colorful, 8-page brochure featuring the recently completed Ilg Research Laboratory in Chicago. Printed in two colors, this new booklet is almost entirely pictorial and contains "workshop" scenes which show the testing and research processes continually taking place in the building. Brief captions and a short summary descriptive of the Laboratory form the balance of the booklet.—*Ilg Electric Ventilating Co., 2850 North Crawford Ave., Chicago 41, Ill.*

Industrial Heating

A portfolio, beautifully arranged and illustrated, entitled "Portfolio of Outstanding Engineering in Industrial Heating," bulletin 512, and devoted to the company's direct-fired warm air industrial heating systems. The illustrations cover many of the great war structures heated by this method.—*Dravo Corp., Dravo Bldg., 300 Penn Ave., Pittsburgh, Pa.*

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FROM CLOGGING STEAM EQUIPMENT

YARWAY STRAINERS

"The Screen's the Thing"

- *A High Grade Monel Woven Wire Basket* with mesh fine enough to catch the dirt — yet ample free area for passage of clean condensate, oil and other fluids.
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- *Readily Removed Steel Blow-Off Bushing.*
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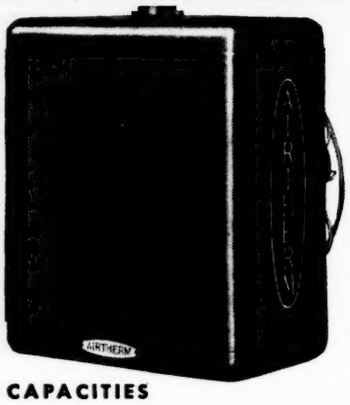
AIRTHERM UNIT HEATERS

Now Available with Copper Coils

Available on AA5, or Better, Priority

Horizontal Unit Heaters

(Copper)

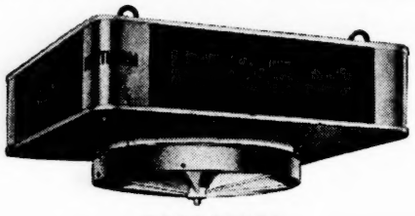


CAPACITIES

Model	Btu/hr.	Motor HP	Motor RPM	CFM	Final Temp. °F.
M-25C	25,400	1/45	1580	410	114
M-35C	35,000	1/33	1580	585	114
M-45C	45,000	1/33	1580	685	118
M-60C	60,000	1/20	1140	1020	114
M-87C	87,000	1/8	1140	1500	113
M-114C	114,000	1/8	1140	1905	114
M-140C	140,000	1/6	1140	2400	113
M-170C	170,000	1/6	1140	2650	118
M-215C	215,000	1/4	1140	3600	114
M-278C	278,000	1/2	1140	4300	118

Btu/hr. computed at 2 lb. gage steam pressure and 60°F. entering air.

Vertical Delivery Unit Heaters



CAPACITIES

Model	Btu/hr.	Motor HP	Motor RPM	CFM	Final Temp. °F.
V-145C	145,000	1/8	1140	2700	114
V-175C	175,000	1/3	1725	3400	111
V-191C	191,000	1/4	1140	3300	118
V-234C	234,000	1/2	1725	4300	114
V-260C	260,000	1/2	1140	4550	115
V-340C	340,000	1/2	1140	5600	120
V-480C	480,000	1	1140	8000	120
V-600C	600,000	1 1/2	1140	11000	115

Send today for bulletin giving complete information and prices.

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COMING EVENTS

DECEMBER 10-13—Annual meeting of the American Society of Refrigerating Engineers to be held at the Hotel Pennsylvania, New York City. Secretary, David L. Fiske, 50 W. 40th St., New York 18, N. Y.

DECEMBER 13-14—Annual convention of the National Warm Air Heating and Air Conditioning Association, to be held at the Hotel Statler, Cleveland, Ohio. Further information from George Boeddener, Managing Director of the Association, 145 Public Square, Cleveland.

JANUARY 8-12—Annual meeting and engineering display, Society of Automotive Engineers, Book-Cadillac Hotel, Detroit.

JANUARY 11-13—Louisiana Engineering Society. Annual meeting to be held at the St. Charles Hotel, New Orleans. Secretary, John K. Mayer, P. O. Station 20, New Orleans, La.

JANUARY 22-24, 1945—51st Annual meeting of the American Society of Heating and Ventilating Engineers, at Hotel Statler, Boston. Secretary, A. V. Hutchinson, American Society of Heating and Ventilating Engineers, 51 Madison Ave., New York.

JANUARY 22-26—Winter technical meeting of the American Institute of Electrical Engineers, 29 West 39th St., New York, N. Y.

SEPTEMBER 17—Third Wartime Conference and 74th Annual Meeting of American Public Health Association to be held at the Hotel Stevens, Chicago, Ill. Executive secretary, Reginald M. Atwater, M.D., American Public Health Association, 1790 Broadway, New York 19, N. Y.

WHAT READERS SAY

Central Heating

EDITOR, HEATING AND VENTILATING:

It appears that in my article Central Heating for Large Building Groups [HEATING AND VENTILATING, Nov., 1944] I have led some of your readers to believe that I recommend all central plants be designed for 125 lb gauge.

The boiler pressure should be determined by two factors:

1. The length of the underground steam distribution should not exceed 1500 feet exclusive of fittings and valves to operate at less than 15 lb gauge for quality steam;

2. A heat balance should be made to determine what pressure will be most economical to use where the underground steam lines exceed 1500 feet.

P. A. Croney

Newton, Massachusetts.

Sol-Air Temperature

(Concluded from page 66)

for the horizontal surface. Engineers may contribute to this study by an acceptance of some standard values of the combined film coefficient of heat transfer as a function of air movement, and by obtaining more reliable data for the solar absorptivities of various typical building surfaces and for the solar absorptivity and solar transmissivity of typical window glass, single and double, as a function of the angle of incidence of the sun's rays. Summer and winter weather data for many different localities, translated in terms of design sol-air temperatures, would provide the facts that are so necessary for engineering analysis.

REFERENCES

1. Transactions, A.S.H.V.E., 1934, p 114.
2. Monthly Weather Review, December, 1937, p 437.
3. Air Conditioning Principles, by C. O. Mackey, International Textbook Company, p 136.
4. Transactions, A.S.H.V.E., 1935, p 341.
5. Transactions, A.S.H.V.E., 1930, p 429.

INDUSTRIAL DEGREE DAYS
September and October, 1944

City	Number of Industrial Degree Days			
	55F Base		45F Base	
	September	October	September	October
Baltimore	0	49	0	0
Buffalo	17	189	0	34
Chicago	5	123	0	2
Cleveland	10	125	0	5
Detroit	5	136	0	6
Indianapolis	0	76	0	0
New York	0	77	0	5
Philadelphia	0	55	0	1
Pittsburgh	2	90	0	4
St. Louis	0	19	0	0

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American Welding Society, 29 W. 39th St., New York.
(Ordnance Distinguished Service award)

General Controls Co., Glendale, Calif.
(Addition of White Star)

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(Fourth star)

Fitzgibbons Boiler Co., Inc., Oswego, N. Y.
(Second star)

The Rudy Furnace Co., Dowagiac, Mich.

Buffalo Forge Co., Buffalo 5, N. Y.
(Third renewal)

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DEHYDRATING . . .
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Young coils embody many exclusive construction features . . . are made of quality materials . . . are thoroughly tested and accurately rated.

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APPLICATION ENGINEERS IN PRINCIPAL CITIES

Young standard coils for such requirements as fan blast heating and ventilating systems, air conditioning units, dehydrating tunnels and bakery proof-boxes.
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Expansion-arm type quick break thermostats for accurate temperature control of liquids from 125° to 200° Fahrenheit.

2 pole 30 amp. 230 volts AC
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Bimetal quick break thermostat for clamping to curved or flat surfaces.

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PROVIDES MAXIMUM EFFICIENCY
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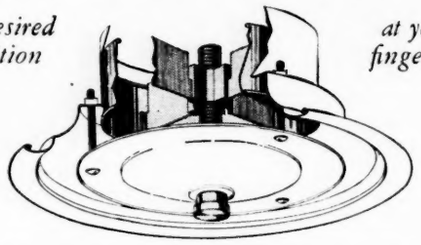
Any desired condition *at your finger tip*



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Patented

All Kno-Draft Air Diffusers are also equipped with *air direction* adjustment to suit seasonal or individual requirements. Their engineered design insures more effective room air mixing, more uniform room temperature and controlled, noiseless, draftless air diffusion at low cost.

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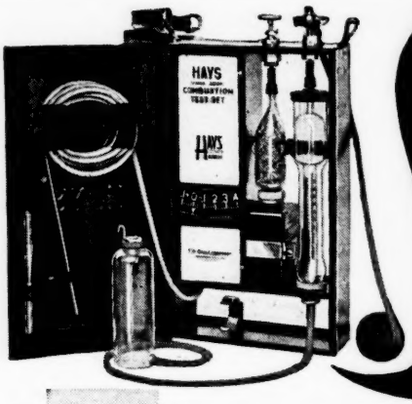

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Portable
SIZE OF CASE 7⅞"x5"x15" HIGH WEIGHT 9 LBS.

For accurate, quick combustion analysis. Combines single unit gas analyzer with a diaphragm type draft gage and flue gas thermometer. Completely enclosed in steel case with leather handle, weight 9 lbs. Of particular benefit to service and heating engineers and installers of oil and gas burners, stokers, furnaces, and boilers. Full details in Bulletin 43-362.

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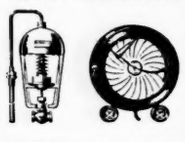

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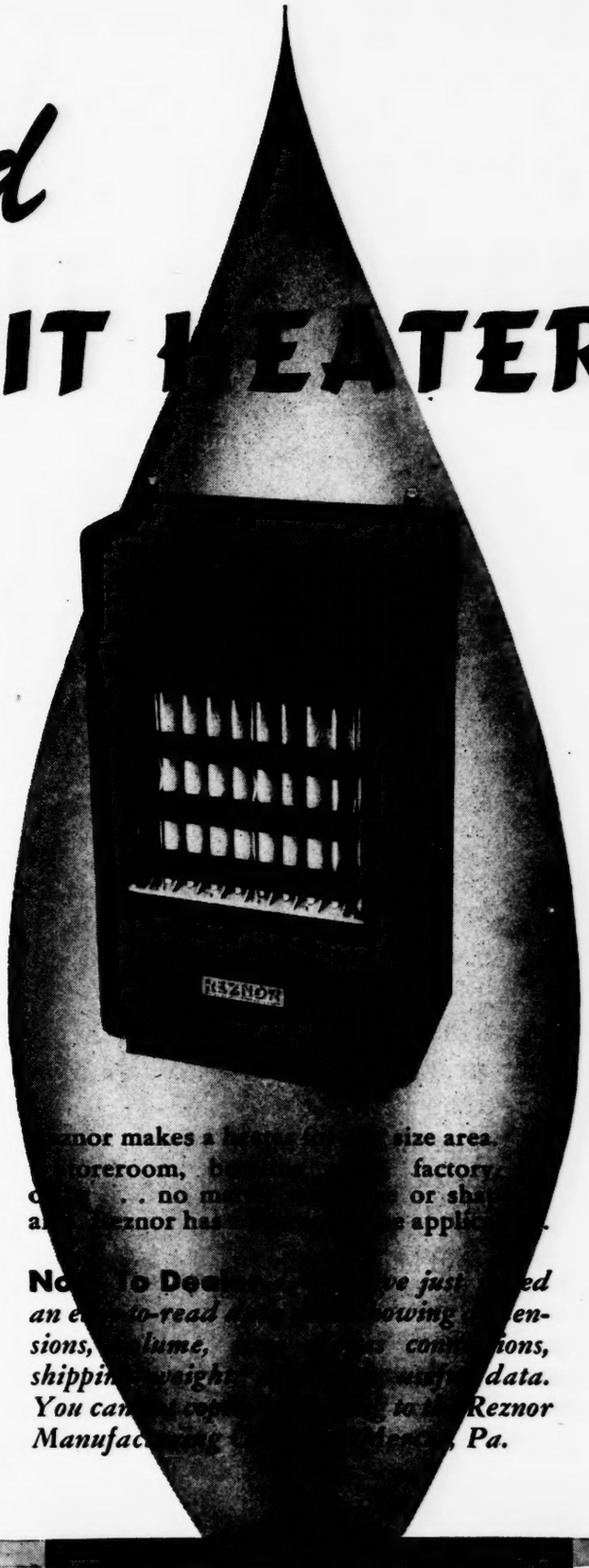
Gas-fired
REZNOR UNIT HEATER



A Complete Self-Contained Heating Plant

Pay Only For Heat You Use

With a Reznor, you have heat when you want it — where you want it.

Automatic control with thermostat or hand control.

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Due to wartime shortages, you may not be able to get your Reznor immediately. On future orders, we regret to announce that we cannot offer any definite delivery promises.

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To conserve space, you can suspend the Reznor Unit Heater.

Installed in a jiffy by a competent Reznor dealer or your own plant men.

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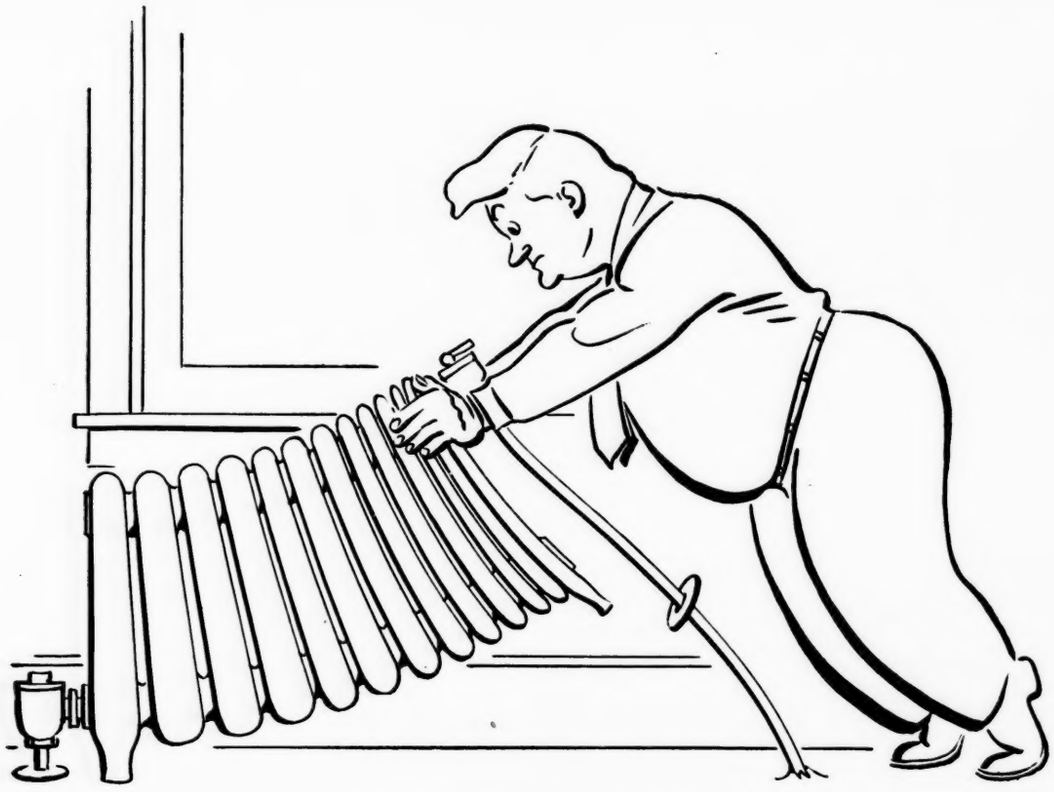
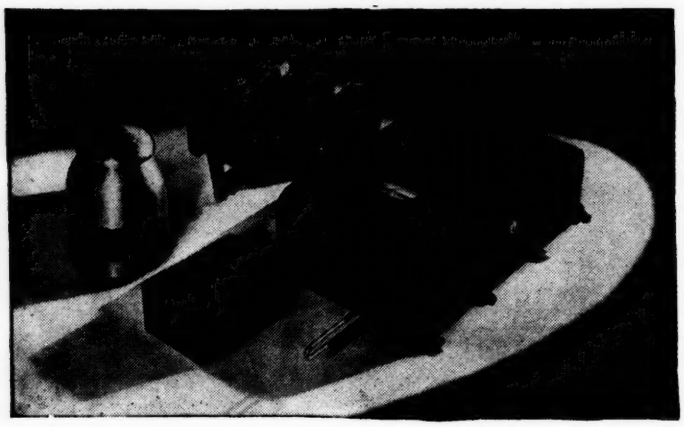


Flexible Heat...

With a Webster Moderator System, radiators are "flexible." In coldest weather, the entire radiator is in use and filled with steam. In mild weather, steam delivery to radiators shrinks to the needed quantity. The amount of steam delivered to a radiator depends not on the size of the radiator, but on outside temperature.

With a Webster Moderator System, just enough steam is delivered to each radiator to keep you comfortable at that particular time. There's no waste of valuable fuel through overheating or underheating. An Outdoor Thermostat automatically changes the heating rate to agree with changes in outdoor temperature.



The Webster Moderator System assures prompt heating-up, balanced distribution of steam and even room temperature throughout the building.

More Heat with Less Fuel

Webster Engineers have discovered through surveys of thousands of buildings that seven out of ten large buildings in America (many less than ten years old) can get up to 33% more heat from the fuel consumed.

If you're interested in flexible, adequate heating, write for "Performance Facts". This free booklet contains case studies of 268 modern steam heating installations and shows the great savings possible with the Webster Moderator System of Steam Heating.

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Pioneers of the Vacuum System of Steam Heating : : Est. 1888
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In the Webster Moderator System of Steam Heating there are just four control elements—an Outdoor Thermostat, a Main Steam Control Valve, a manual Variator and a pressure control Cabinet. These controls are an integral part of the Webster System...asuring the highest expression of comfort and economy in modern steam heating.

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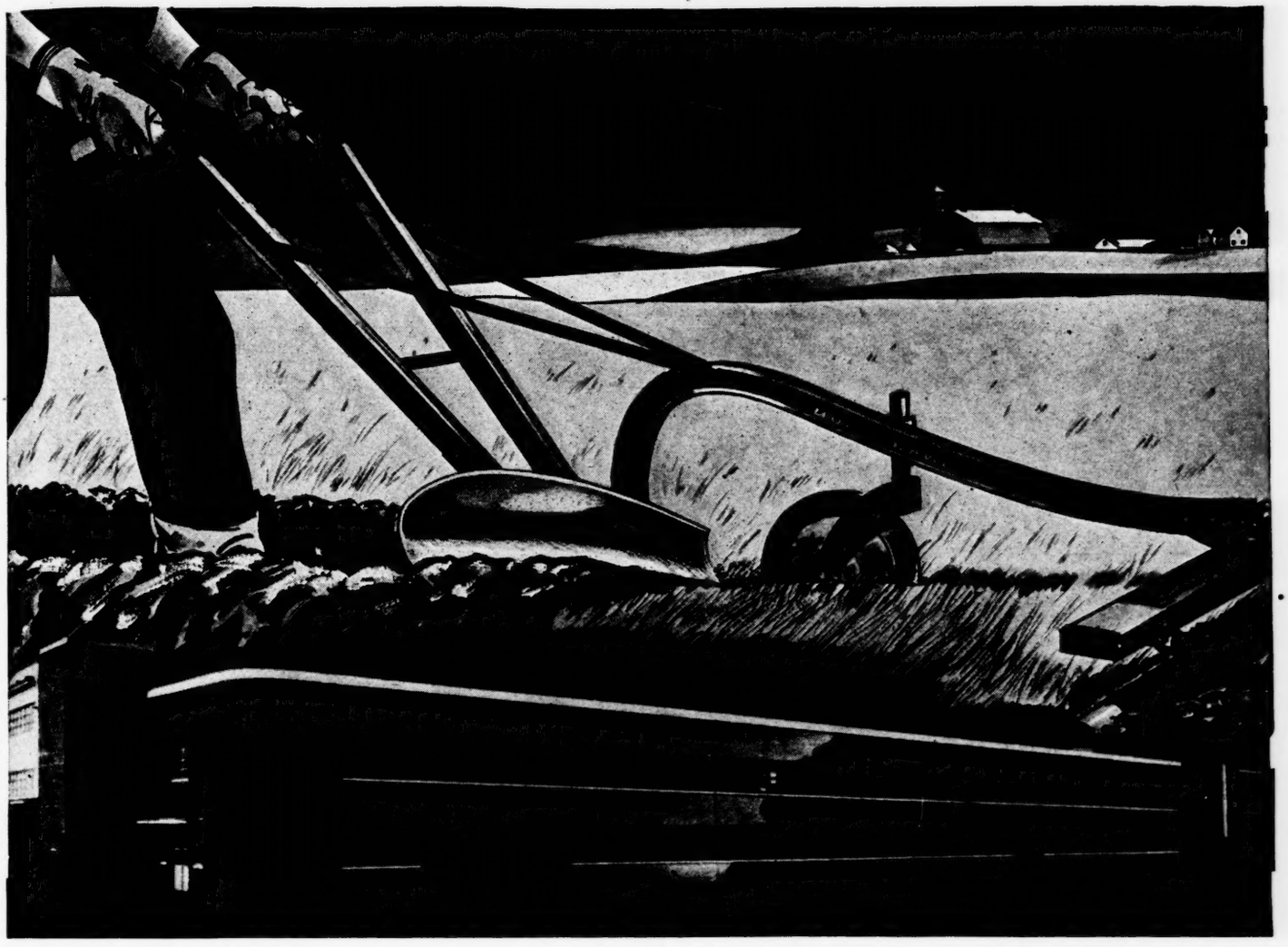
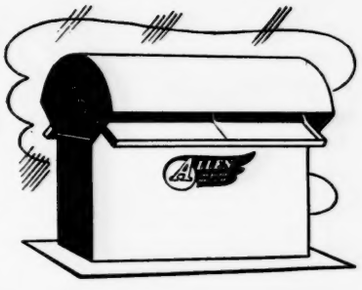
AUTOMATIC Webster Steam Heating



More than a quarter million dollars plowed back to American industry

by One Allen Ventilating Unit...



Ventilation that does the job comes first with Allen. Close on the heels of that consideration comes lowered cost to the buyer. Only when we click on both are we satisfied, because only then do we know we've done the right kind of job.

Basically better ventilation engineering has enabled Allen to furnish industry with more than four thousand Allen Type "H" Roof Fans at an average saving of $62.50 per unit over the nearest comparable equipment—more than a quarter million dollars.

The explanation is simple. Allen patents cover the use of dampers balanced in the effluent air stream—open when the fan is running, closed automatically when power is off. This is in contrast to construction used by several other manufacturers wherein mechanical, motor-operated dampers are mandatory and up the cost.

Approximately 400 of these Allen units top the huge Willow Run Bomber Plant, shown above. Allen has an answer for your ventilation problem, too, whether it's ordinary or extraordinary. Let's talk it over. *The Allen Corporation, 9751 Erwin Avenue, Detroit 13, Michigan.*

SOME TYPICAL USERS OF ALLEN TYPE "H" UNITS

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BUNDY TUBING COMPANY
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FISHER BODY DIVISION
FORD MOTOR COMPANY
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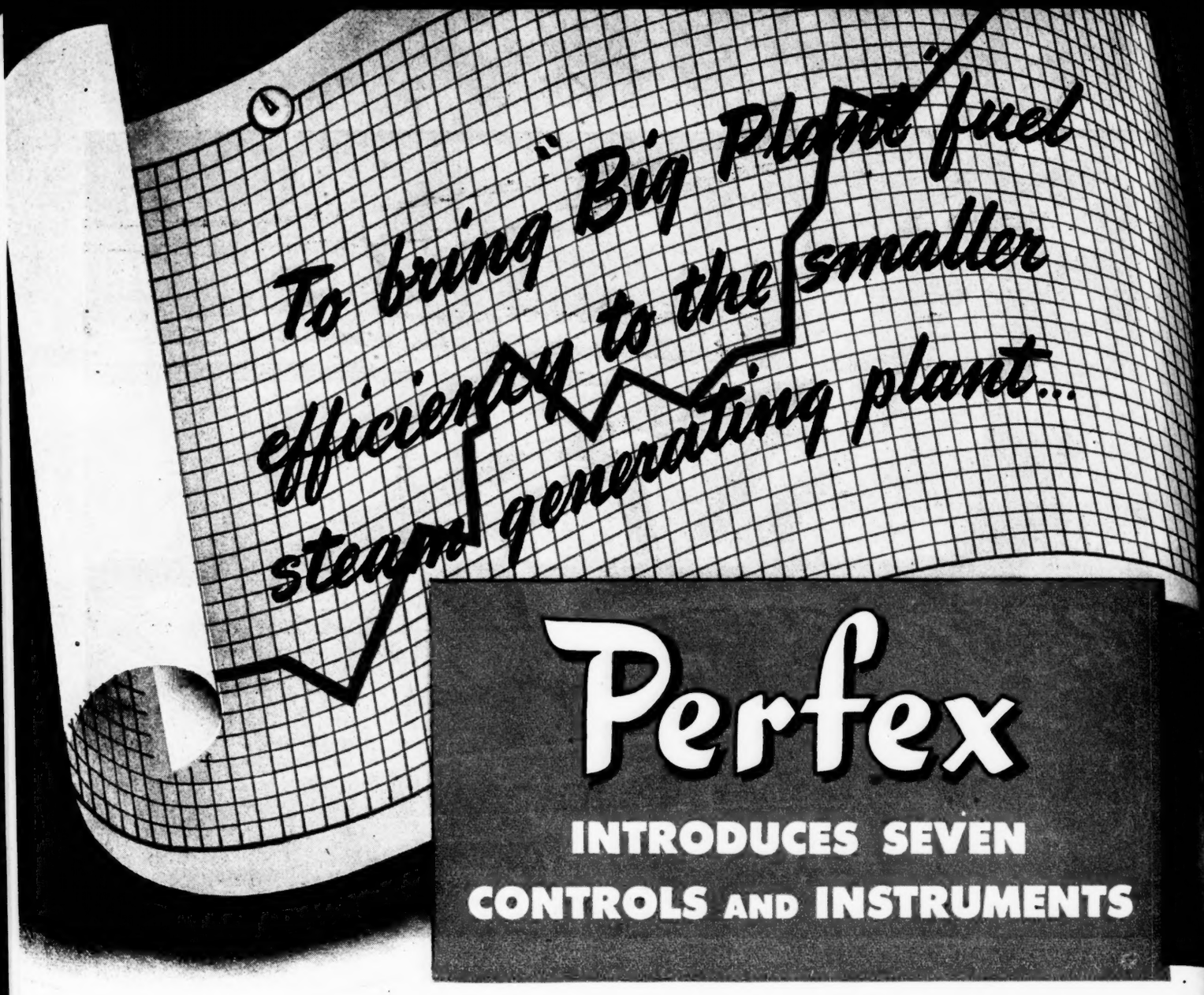
BROOKLYN NAVY YARD
SERVEL, INCORPORATED
A. C. SPARK PLUG
GAR WOOD INDUSTRIES

THE *Allen* CORPORATION

ENGINEERED VENTILATION FOR INDUSTRY


To bring Big Plant fuel efficiency to the smaller steam generating plant...
Perfex
INTRODUCES SEVEN
CONTROLS AND INSTRUMENTS

for Apartments, Hotels, Office Buildings, Schools, Stores, Industrial Boilers, etc.

Hit-or-miss, uncontrolled combustion is today's greatest cause of fuel waste. Industrial and heating boilers that are not under proper control do not derive the maximum of useful heat from fuel burned, are incapable of maximum ratings, and add considerably to operating cost.

Now this waste can be corrected. You can achieve "big plant" fuel burning efficiency in the smaller steam generating plants that you design, install, service, or operate.

These new units pay for themselves within a short time, and — what is even more important — will continue to effect fuel savings year after year. Each control and instrument in this new Perfex series features new basic engineering advances. Every heating and power engineer, plant management executive, and building operator should investigate these controls now . . . to achieve maximum fuel economy.

Fuel-Saving Starts With CONTROL

Perfex CORPORATION

515 WEST OKLAHOMA AVENUE • MILWAUKEE 7, WISCONSIN

The ACTUATOR The heart of a control system is the moving device. The Perfex Actuator is a rugged, powerful positioning unit furnishing positive straight-line movement adjustable from 2" to 6". It exerts a draw-bar lift of 300 pounds. It responds to remote control from draft or combustion controls to operate dampers, lever valves, rheostats, blast gates, modulated stokers, and full automatic oil burners.

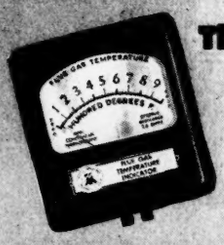
The DRAFT CONTROL Used with Perfex Actuator, regulates outlet damper in response to slight changes in over-fire draft. Its dry diaphragm and 115-volt snap-action switches operate on adjustable, slight differentials. Desired draft rate is maintained within total range of .02", operating on .01" variation from adjusted rate. May be used to operate any three-wire switching mechanism for controllers other than Perfex Actuator.

The COMBUSTION CONTROL Operates Perfex Actuator in response to slight steam pressure changes to control stoker or oil burner fuel and air feed or dampers. Step regulation features easy adjustment of step length. Incorporates secondary control circuit for "over-control" from weather, process, or time. Brings standard of performance formerly available only to large plants into popular price field.

The DAMPER PROGRAM CONTROL Provides low "stand-by" draft to effect enormous fuel saving during the "off" periods for "on-and-off" stokers and oil burners. Meets Underwriters' requirements by opening stack damper before automatic firing equipment starts, then returning regulation to the Perfex Draft Control when stoker or oil burner is in operation.

The DRAFT GAGE The first requirement in your campaign to increase efficiency, the most needed instrument in the boiler room, the Perfex Draft Gage is a single pointer, large scale, easy-to-read instrument for indicating over-fire draft or boiler outlet draft. It features a dry diaphragm and its simple and accurate mechanism assures accuracy and long life.

The PRESSURE GAGE An absolute "must" for efficient forced-draft solid fuel firing. The Perfex Pressure Gage accurately measures and indicates the pressure under the grate, and, therefore, indicates the condition of the fuel bed. Clinker formations and "blow-holes" are instantly detected through rising or falling pressure, enabling the operator to correct such conditions before serious fuel losses occur.



The FLUE GAS TEMPERATURE INDICATOR This much-needed instrument furnishes a final check on all phases of boiler operation by measuring and indicating temperature of the flue gases. Incorporates automatic compensation for ambient temperature, and, therefore, its constant indication is direct and accurate. Long connecting cables permit installation at point where instrument may be most easily read, thereby assisting operator. Instantly indicates heat losses caused by "sooting" and excessive draft.

Free Book Mail To day

PERFEX CORPORATION
515 W. OKLAHOMA AVE.

Send today for your free copy of this valuable book that tells how Perfex Controls and Instruments increase the efficiency of steam production.

Name .....

Address .....

City ..... *State* .....

Efficient AIR VALVES SAVE FUEL

In many home heating plants, radiator air valves go untouched for years. Inefficient or sluggish action in venting air from radiators and steam lines causes a great waste of fuel.

That's not only very serious now that fuel is scarce, but it causes much unnecessary discomfort.

You can render an important service by bringing this matter to the attention of your customers, inspecting their heating systems and replacing old slow venting or clogged valves with the proper type of Detroit valve.

There is a type for every one pipe steam system—hand fired or automatic, new or old—providing a reliable venting system which will result in a saving of fuel and greater comfort.

NO. 300 MULTIPORT—Adjustable large port fast-venting radiator air valve with controlled minimum venting rate and patented "Automatic Modulator." For pressures under 3 pounds.

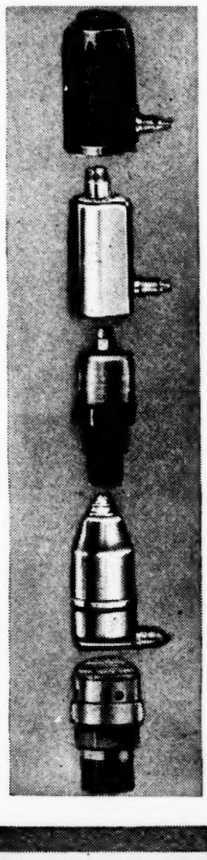
NO. 5000 AIRID VARIPORT—Adjustable, large port air valve for systems operating at pressures above 3 pounds.

NO. 861 HURIVENT—For mains. Has full ½" port opening. Closes against water. • The No. 300 or No. 5000 together with the No. 861 make up the famous Ideal Fast Venting System which provides maximum comfort and greatest fuel savings on automatically fired jobs.

NO. 500—Inexpensive Non-adjustable Valve. For many years a favorite with heating men. For both hand fired and automatically fired one pipe steam systems.

NO. 841 QUICK VENT—Inexpensive yet highly efficient main line vent with full ¼" port opening.

ALSO—Vacuum valves for hand fired systems.



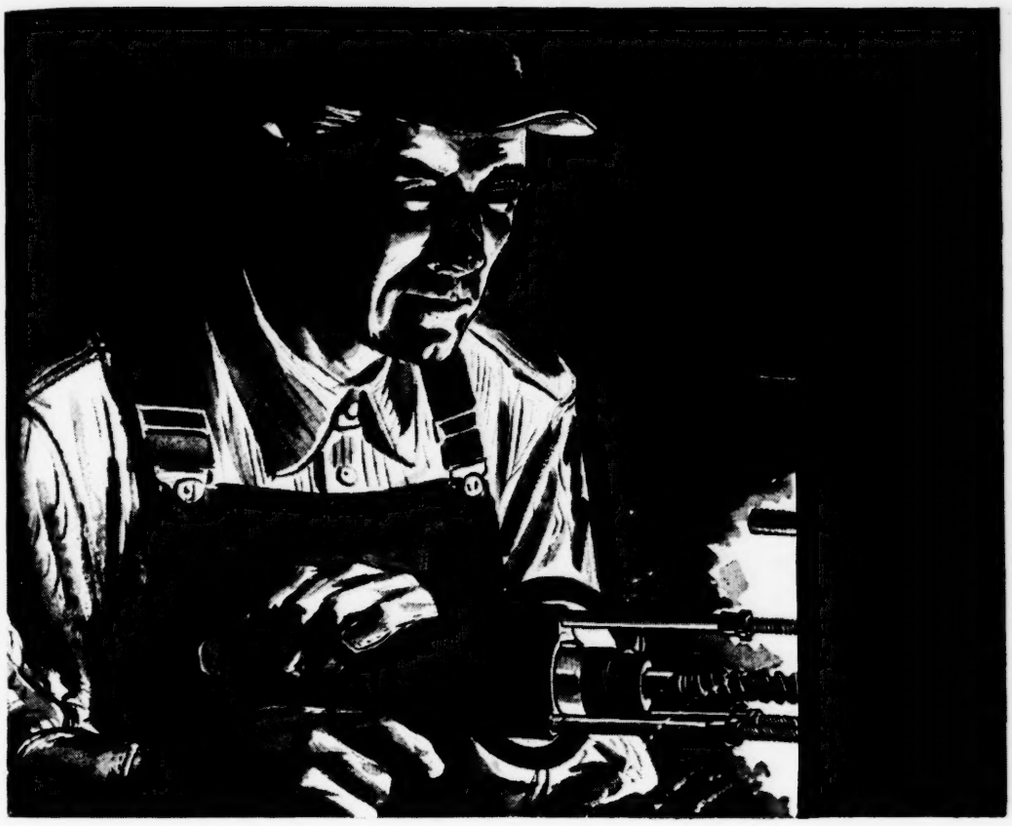
DETROIT LUBRICATOR COMPANY

General Offices: DETROIT 8, MICHIGAN

Canadian Representative—RAILWAY AND ENGINEERING SPECIALTIES LIMITED, MONTREAL, TORONTO, WINNIPEG

Division of AMERICAN RADIATOR & Standard Sanitary CORPORATION

"DL" Heating and Refrigeration Controls • Engine Safety Controls • Safety Float Valves and Oil Burner Accessories • Radiator Valves and Balancing Fittings • Arco-Detroit Air and Vent Valves • "Detroit" Expansion Valves and Refrigeration Accessories • Air Filters • Stationary and Locomotive Lubricators.

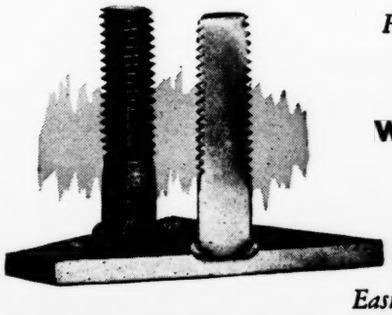


Complete fusion of stud to metal in less than 1/2 second...

The Nelson Stud Welder is simple to operate because the welding is *automatically* controlled. It eliminates the need for drilling, tapping, and hand welding bolts to secure parts, because it end-welds studs directly to the metal surface.

It is used by more than 460 industrial plants and shipyards. Operators are securing 500 to 1500 studs a shift. No previous welding experience is necessary to operate it.

Complete fusion of the stud to metal is obtained by accurate arc timing control, automatic action of the "gun," the use of flux-filled studs, and complete shielding of the arc.



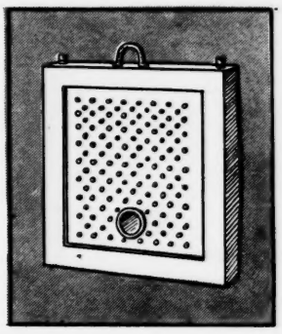
Cutaway view of stud, after etching with Nital.

For complete data, catalog and price list, write:

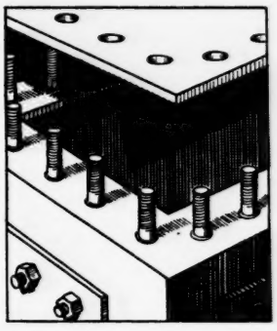
NELSON SPECIALTY
WELDING EQUIPMENT CORPORATION
Dept. H, 440 Peralta Avenue
San Leandro, California

Eastern Representative: Camden Stud Welding Corp. Dept. 22, 1416 South Sixth St., Camden, N. J.

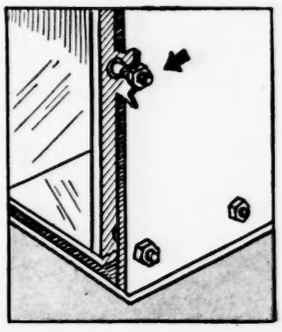
TYPICAL STUD APPLICATIONS



Hearth Door – Refractory ore is secured to doors and reinforced by means of studs. Studs are welded to the metal doors and the ore packed around them. Increases the life of the door, saves time and material.



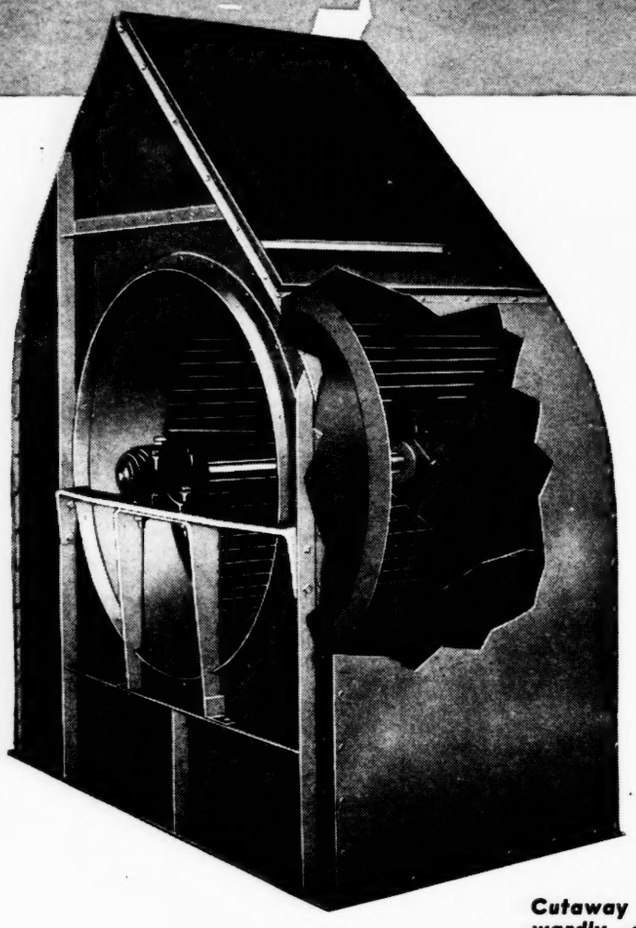
Inspection covers of all types can be secured with Nelson Studs. No drilling holes through casings, or hand welding studs. Studs are automatically welded in less than ½ second. No leaking or loosening.



Metal Liners – To obtain a blemish-free lining to prevent the eroding action of particles that may be drawn through air-pumps, etc. Studs are welded to back of inner lining and secured on outer casing. Useful in manufacture of air-conditioning equipment.

NELSON STUD WELDERS & STUDS

Herman Nelson Centrifugal



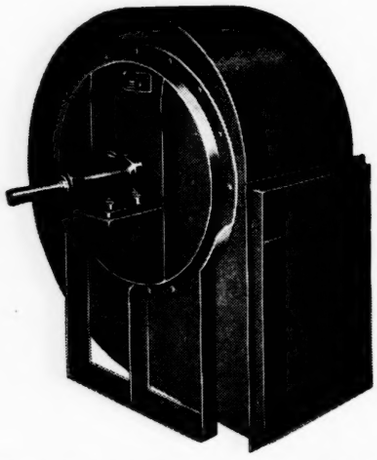
. . . for heating, cooling, ventilating, air conditioning and process applications

Today practically every heating, cooling, ventilating, air conditioning or processing problem calls for the movement of air. Often this problem of air movement can best be solved by the use of a blower. Not just any blower, but a blower designed and constructed for the performance required by a particular application.

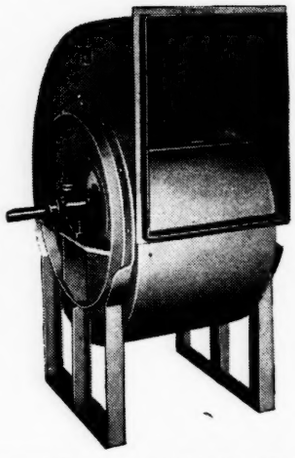
The Herman Nelson Corporation, manufacturer of blowers for over thirty years, is in a position to furnish blowers for most of these applications. Herman Nelson blowers with wheel diameters from 6″ to 73″ deliver from 250 to 308,200 cu. ft. of air per minute. Arranged for either belt or direct drive, they are available with forwardly or backwardly curved blades. Both single inlet single width and double inlet double width blowers may be operated against static pressures up to 5″ W.G. and will handle air up to 700° F. They are available with top horizontal, bottom horizontal, up blast, down blast, or angular discharge and either clockwise or counter-clockwise rotation. If we haven't the blower for your application, we will tell you.

The next time you have a heating, cooling, ventilating, air conditioning or processing problem, contact the Herman Nelson distributor in your locality or write to us and we will have a Herman Nelson Product Application Engineer contact you.

Cutaway view of a forwardly curved blade SI SW, Arrangement 3, angular discharge, Herman Nelson Blower.

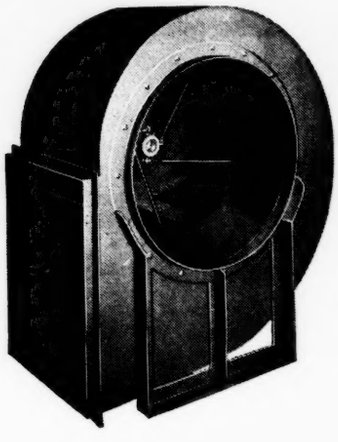


Forwardly curved blade, SI SW, Arrangement 2, bottom horizontal discharge, Herman Nelson Blower.

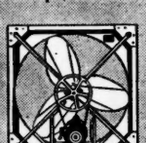


Forwardly curved blade, SI SW, Arrangement 3, top horizontal discharge, Herman Nelson Blower.

Backwardly curved blade, SI SW, Arrangement 1, bottom horizontal discharge, Herman Nelson Blower.



Herman Nelson Direct Drive Propeller Fans



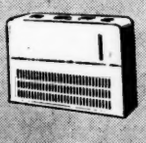
Herman Nelson Belt Drive Propeller Fans

Herman Nelson Horizontal Shaft Propeller-Fan Type Heaters

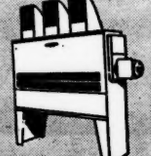
Herman Nelson Vertical Shaft Propeller-Fan Type Heaters

Herman Nelson Belt Drive Unit Blowers

Herman Nelson Direct Drive Blowers

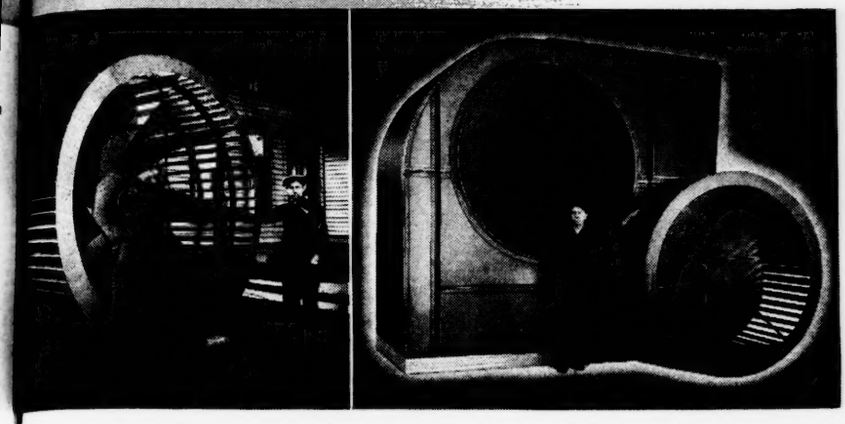


Herman Nelson De Luxe Heaters



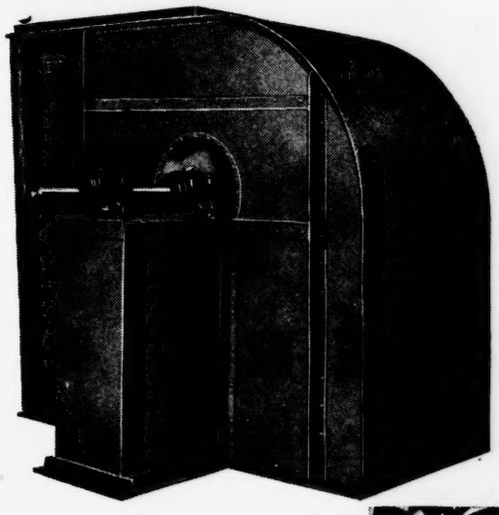
Herman Nelson Blower-Fan Type Heaters

Blower Fans

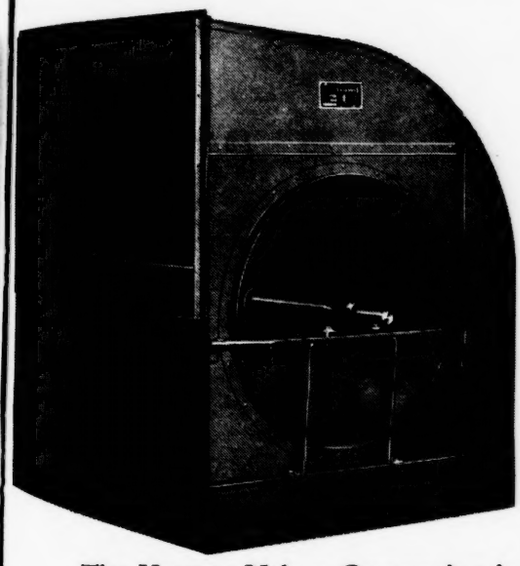


OLD TIME, special SI SW Herman Nelson Blower built in 1917 for American Smelting and Refining Company. Capacity 272,000 c.f.m. at 200 RPM; belt-drive; overhung wheel; the water-cooled bearings weighed 3,200 lbs.; wheel diameter 120", width 64"; height of housing 240"; outlet, 122" x 78".

MODERN, standard SI SW Herman Nelson Blower, Type H, Unit 12, built for Central High School of Needle Trades, N. Y. City. Capacity 54,400 c.f.m. at 142 RPM; belt-drive; centerhung wheel (Arr. 3); ball bearings; wheel diameter 75", width 37½"; height of housing 123"; outlet 80¼" x 56¼".

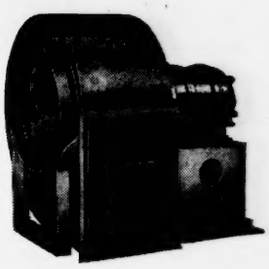


Forwardly curved blade, SI SW, Arrangement 1, up blast discharge, Herman Nelson Blower.

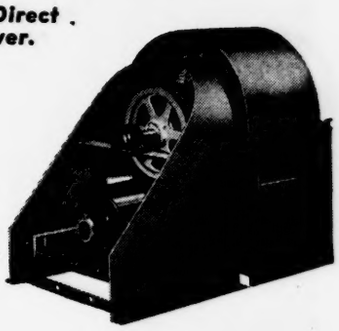


Backwardly curved blade, DI DW, Arrangement 3, top horizontal discharge, Herman Nelson Blower.

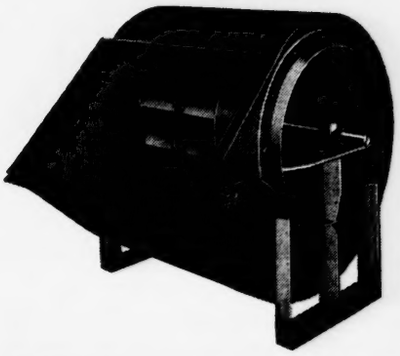
Herman Nelson Direct Drive Unit Blower.



Herman Nelson Direct Drive Unit Blower.

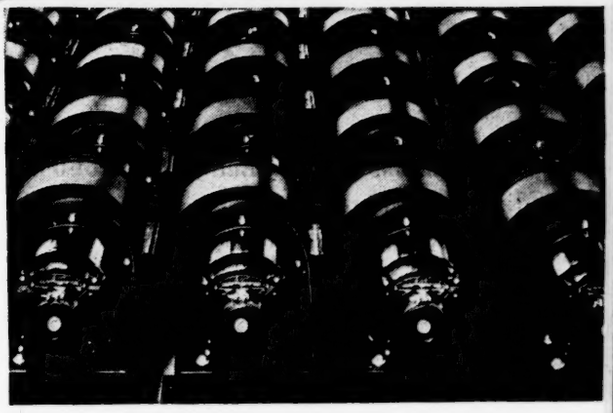


Herman Nelson Belt Drive Unit Blower.



Backwardly curved blade, DI DW, Arrangement 3, bottom angular up discharge, Herman Nelson Blower.

Part of a shipment of 1015 Herman Nelson Blowers used in heating trailers for the armed forces.



The Herman Nelson Corporation is a member of the National Association of Fan Manufacturers. Herman Nelson blowers are tested and rated in accordance with the standard test code as adopted by the National Association of Fan Manufacturers and the American Society of Heating and Ventilating Engineers.

herman nelson

THE HERMAN NELSON CORPORATION

Manufacturers of Quality Heating and Ventilating Products

GENERAL OFFICES: MOLINE, ILLINOIS • FACTORIES AT MOLINE AND CHICAGO, ILLINOIS

A BASIC PRINCIPLE—RADIAL DESIGN . . . EXCLUSIVE FEATURES—VARIABLE CAPACITY AND UNLOADED STARTING . . . PLUS, LIGHT WEIGHT —INTERCHANGEABLE PARTS AND DIRECT CONNECTED . . . VIBRATIONLESS OPERATION . . . MAKE THE FAMOUS CHRYSLER AIRTEMP COMPRESSOR AN OUTSTANDING VALUE.

CHRYSLER AIRTEMP

VARIABLE CAPACITY RADIAL COMPRESSOR

Offers Many Advantages

The time has passed when tough problems in air conditioning and refrigeration can be solved by ordinary, outmoded methods and apparatus.

The war has created a field laboratory in which the hidden qualities of equipment show up in new performance standards that are winning international recognition in the case of Chrysler Airtemp radial compressors.

Ease of installation, reduction of vibration, the sturdy vital Superfinished parts are making smooth, troublefree operation as impressive as economy and long life.

Holding constant temperature-humidity levels is the final test that marks Chrysler Airtemp Heavy Duty Units as ideal from every standpoint. Put them to work for you . . . it pays! • Airtemp Division of Chrysler Corporation, Dayton 1, Ohio. • In Canada, Therm-O-Rite Products, Limited, Toronto, Ontario.

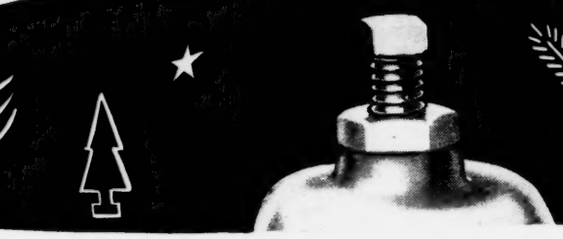
Buy More War Bonds! Tune in Major Bowes every Thursday, CBS., 9 p. m., E. W. T.

CHRYSLER AIRTEMP

HEATING • COOLING • REFRIGERATION

CASH-ACME

EXTEND TO THEIR MANY CUSTOMERS
THE SINCERE WISH FOR A



Merry Christmas
AND A PROSPEROUS SUCCESSFUL

New Year

In Automatic Valves...
IT'S *THIS* NAME THAT COUNTS!
CASH-ACME
VALVE DESIGNERS & BUILDERS FOR *Over Twenty Years!*

A. W. CASH VALVE MFG. CORP.
WABASH & MORGAN — P. O. BOX 247
DECATUR (ZONE A) ILLINOIS

Seven Families

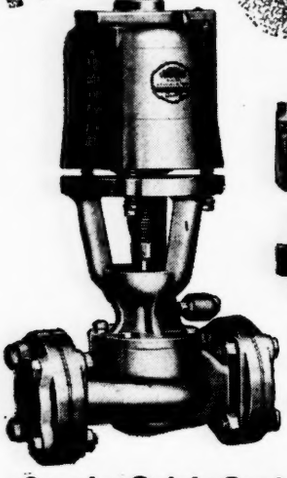
SEVEN ZONES

Owner—W. H. Smith, Riegelsville, Pa.
Contractor—Nelson Shober, Easton, Pa.
Wholesaler—H. P. Kinsey Co., Easton, Pa.

Thrush ZONE CONTROL

FORCED HOT WATER HEAT

for Real Heating Efficiency



Thrush Flow Control Valve

Thrush Water Circulator

Supply Quick Controlled Heat

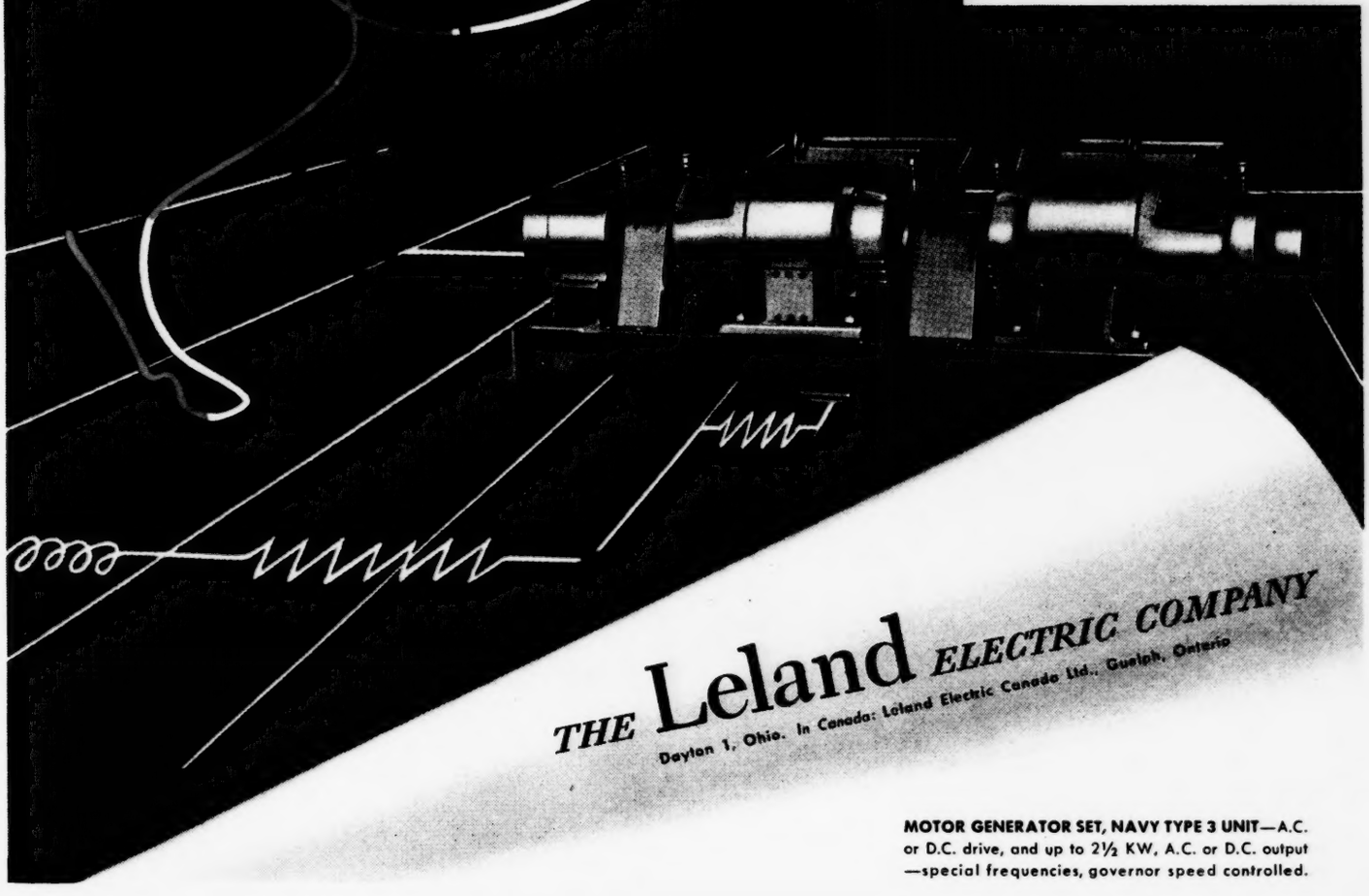
THE owner of this forty-two room apartment building is surely enthusiastic about Thrush Zone Control Hot Water Heat. As the building was being completed, he collected $1,000 in rentals only because he could rent some apartments before all were finished, *since he could furnish heat to any one as needed without heating the untenanted part of the building.* With Zone Control each family enjoys the degree of heat preferred and none must regulate his living habits to suit those of any other tenant. The total amount of fuel saved because of this flexibility pays a real dividend to the owner every year. Tell the apartment house operators of your community about Thrush Zone Control forced circulating hot water heat and you'll get the business. Ask your wholesaler about it or write Dept. D-12.

THRUSH & COMPANY

CREATIVE ELECTRICAL ENGINEERING

Industry is entering an era of electronics, marked by the keenest competition in business history. The rich rewards will surely go to those who employ *Creative Electrical Engineering* to best advantage.

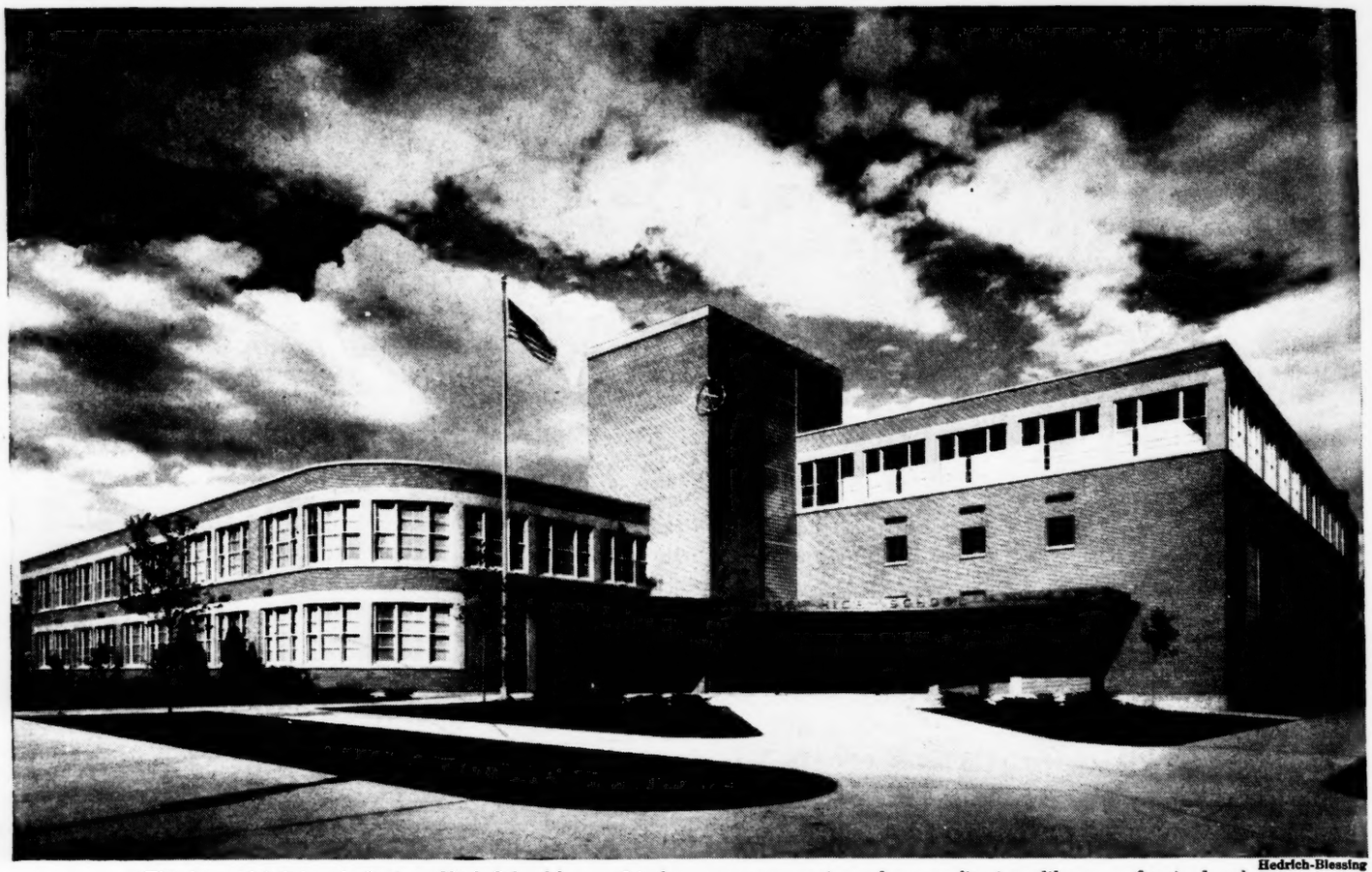
In this highly technical field, LELAND Electric has solved many difficult electrical problems with skill and ingenuity. This valuable experience may be the key to your post-war plan. We invite your inquiry.



THE Leland ELECTRIC COMPANY

Dayton 1, Ohio. In Canada: Leland Electric Canada Ltd., Guelph, Ontario

MOTOR GENERATOR SET, NAVY TYPE 3 UNIT—A.C. or D.C. drive, and up to 2½ KW, A.C. or D.C. output —special frequencies, governor speed controlled.



Hedrich-Blessing

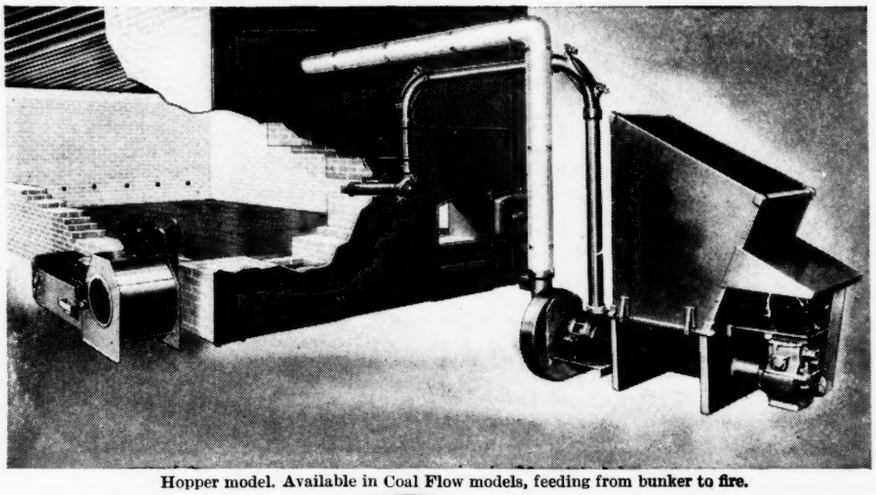
This beautiful Colorado Springs High School houses 34 classrooms, gymnasium, shops, auditorium, library, cafeteria, band and choral rooms, various specialized classrooms, offices, heating plant. Burhham Hoyt and Edward L. Bunts, Architects

Iron Fireman Heats 300% More Space at 9% Less Cost

Iron Fireman Stokers are profitable investment at Colorado Springs High School

THE first unit of the Colorado Springs High School was one-third the size of the present building. In 1939 the building was expanded to its present form, at which time the heating plant was equipped with two Iron Fireman Pneumatic Spreader stokers. The first unit previously was heated with hand-fired coal, at an average annual fuel cost of $2,846. With Iron Fireman stokers, heating three times more space, the average annual fuel bill dropped to $2,599.

You can find out what Iron Fireman will do for *your* heating plant by requesting a free engineering survey. No obligation. Iron Fireman's engineering and service network covers the continent. Write to IRON FIREMAN MANUFACTURING COMPANY, 3095 West 106th Street, Cleveland 11, Ohio. Other plants in Portland, Oregon; Toronto, Canada.



Hopper model. Available in Coal Flow models, feeding from bunker to fire.

IRON FIREMAN

Automatic Coal Stokers

THE IRON FIREMAN

The IRON FIREMAN PNEUMATIC SPREADER STOKER meters steam size coal from hopper or main coal bunker to transfer housing, where coal is picked up by pneumatic conveyor and delivered to furnace. The conveyor nozzle accurately spreads the larger particles of coal over the entire grate in a shallow, uniform fuel bed. The preheated fines burn in suspension, reducing the cinder carry-over and greatly improving the combustion efficiency and responsiveness, as compared with other stokers which do not preheat fuel.

From billet to bolt

—CIRCLE Ⓑ

● The quality, accuracy and dependability of all circle Ⓑ fasteners are rigidly controlled in one integrated plant —the largest independent in the country—from billet to the finished product.

BUFFALO BOLT COMPANY

ARMY E NAVY

NORTH TONAWANDA, N. Y.

SALES OFFICES IN PRINCIPAL CITIES

◀ The uniform quality of all circle Ⓑ products begins in our own rolling mills.

Factory Rebuilt CURTIS
REFRIGERATION COMPRESSORS
Available for Emergencies

★ Many refrigeration suppliers and dealers are experiencing difficulty in furnishing satisfactory repairs for refrigeration compressors now in service. This is due to limitation orders on new equipment, a serious shortage of manpower, and other conditions beyond their control.

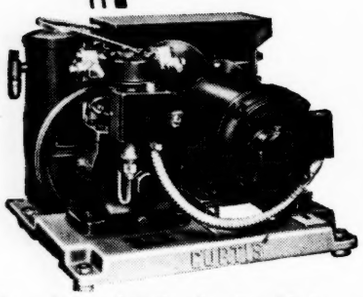
To keep essential Curtis refrigeration on the job while new equipment is restricted for the duration, Curtis reminds you FACTORY REBUILT REFRIGERATION COMPRESSORS are available on an EXCHANGE basis. These compressors are sold in exchange for Curtis compressors needing repairs and are fully guaranteed.

By utilizing this Curtis exchange plan, you can secure a factory-rebuilt and guaranteed Curtis compressor, which will give you long, dependable, and efficient service.

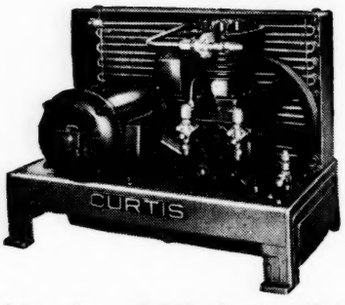
This is but another example of how, despite shortages and limitations, Curtis is making every effort to be of the greatest possible service to dealers and users of Curtis equipment.

Today, Curtis' war job is building more and more Curtis products for our Armed Forces and Essential Industries. This wartime experience, added to that accumulated by Curtis in the past 90 years, assures even finer Curtis equipment for civilian uses after Victory is won.

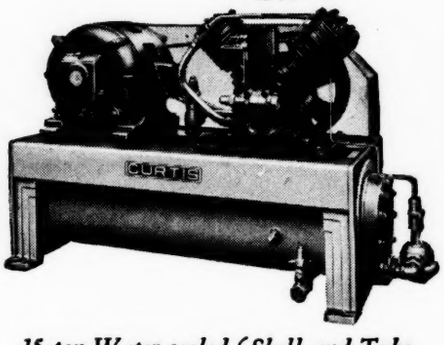
★ ★ ★ ***Conserve Metals — Buy War Bonds*** ★ ★ ★



½ hp. Air-cooled Condensing Unit



1½ hp. Air-cooled Condensing Unit



15-ton Water-cooled (Shell and Tube Type) Condensing Unit

CURTIS
REFRIGERATION
AIR CONDITIONING
COMMERCIAL

CURTIS REFRIGERATING MACHINE DIVISION *of Curtis Manufacturing Company*
1999 Kienlen Avenue, St. Louis 20, Missouri

Will It Help Keep Your Post-War Customers from Getting Hot Under the Collar?

The same Worthington skills that helped design refrigeration equipment for high-octane aviation fuel . . . or helped simulate stratospheric conditions for engine test cells . . . will help *you* obtain the most efficient, trouble-free air conditioning equipment in the competitive days to come.

Why not find out – today – how *many* of the essential parts of an air conditioning system Worthington will be able to supply. In many cases, complete unit responsibility has contributed greatly to economical maintenance and dependable, long-lived performance.

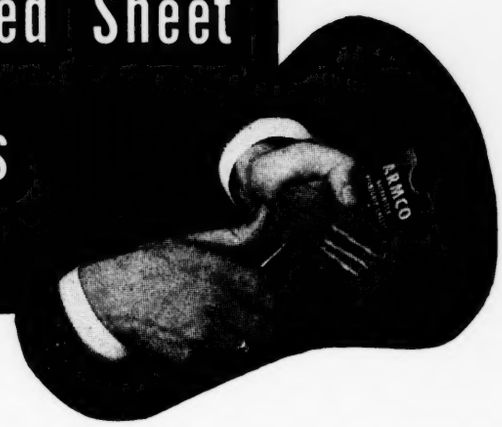
Investigate, also, the many historic air conditioning installations, including the New York Stock Exchange in 1904, which have built up the backlog of Worthington experience on which you – your clients and customers – can rely. Worthington Pump and Machinery Corporation, Harrison, N. J. District Offices and representatives in principal cities.

WORTH BEHIND THE NAME
WORTHINGTON

AR4-9

Refrigeration · Air Conditioning

Here's a PAINTABLE Galvanized Sheet for Your New Peacetime Jobs

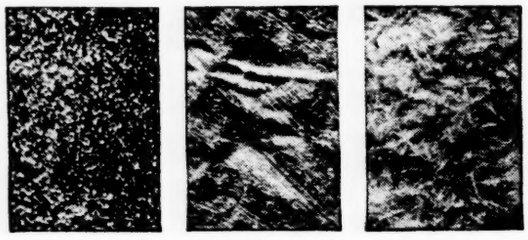


In heating and air conditioning uses—such as furnace casings and exposed air ducts—ARMCO Galvanized PAINTGRIP sheets offer you decided advantages over ordinary galvanized metal.

This *original* Bonderized Galvanized sheet requires no acid etching or weathering. The phosphate film insulates the paint from the zinc and holds paint several times longer than an acid-etched galvanized surface. Photomicrographs tell the story.

The "Scratch" Test

This test shows how paint adheres to PAINTGRIP. The top of the sample is Bonderized. When scratched with a pen knife only a superficial mark is noticeable. Paint on ordinary galvanized (bottom half) comes off readily.

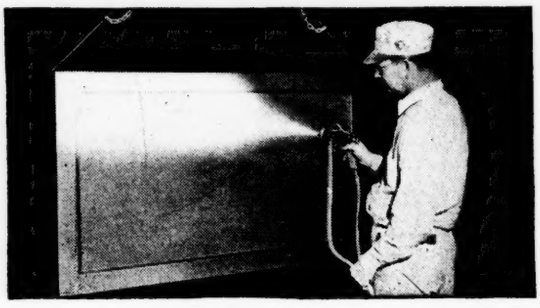


A B C

A This magnification shows that an ordinary galvanized sheet appears slick and difficult to "coat" with paint.

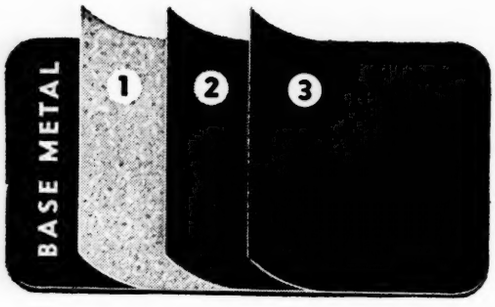
B Ordinary galvanized after acid etching. The etching has removed part of the protective zinc coating.

C Compare the mat-like paint-holding surface of ARMCO PAINTGRIP with that of the others. No coating has been removed and paint is insulated from the zinc.



Immediate Painting

ARMCO PAINTGRIP can be painted immediately. No costly acid etching or primers are needed. Thus the *full weight* of the protective zinc coating is preserved intact.



What Paintgrip Is....

1. A full zinc coating under—
2. ARMCO PAINTGRIP: A mill-applied Bonderized finish that insulates zinc from—
3. Paint or enamel that can be applied in any color.

If you see advantages here for your work, in reducing fabricating costs and stepping up peacetime sales, we'll be glad to discuss the use of ARMCO PAINTGRIP. Write for illustrated booklet. Just address The American Rolling Mill Company, 2081 Curtis Street, Middletown, Ohio.

GALVANIZED PAINTGRIP ARMCO STEEL

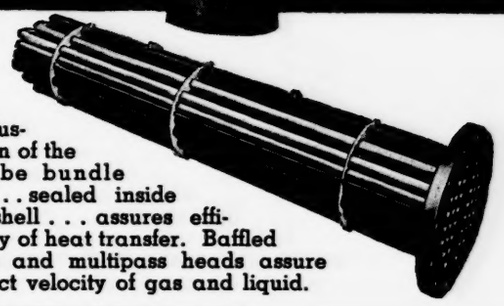
The American Rolling Mill Company

Heat Exchangers

FOR EXCHANGE OF HEAT BETWEEN GASEOUS AND LIQUID REFRIGERANT

FOR ALL INSTALLATIONS UP TO 180 TONS

Acme U-Tube model for big installations



An illustration of the U-Tube bundle that . . . sealed inside the shell . . . assures efficiency of heat transfer. Baffled tubes and multipass heads assure correct velocity of gas and liquid.

U-TUBE MODELS FOR LARGE CAPACITIES

● When compressor capacity is on the border line for load requirements . . . a heat exchanger is most practical assurance for satisfactory performance. Acme has been supplying heat exchangers to the industry for so many years that their performance in actual service is never questioned. For all heavy-duty jobs Acme's Shell and U-Tube models have met every requirement.

Better performance of Acme's U-Tube construction comes only out of 25 years experience in building for the industry. The fact that it increases refrigeration effect . . . that it prevents liquid slugging and sweating suction lines . . . these are facts well known throughout the industry. For complete information write for catalog No. 12.

ACME INDUSTRIES

JACKSON, MICHIGAN

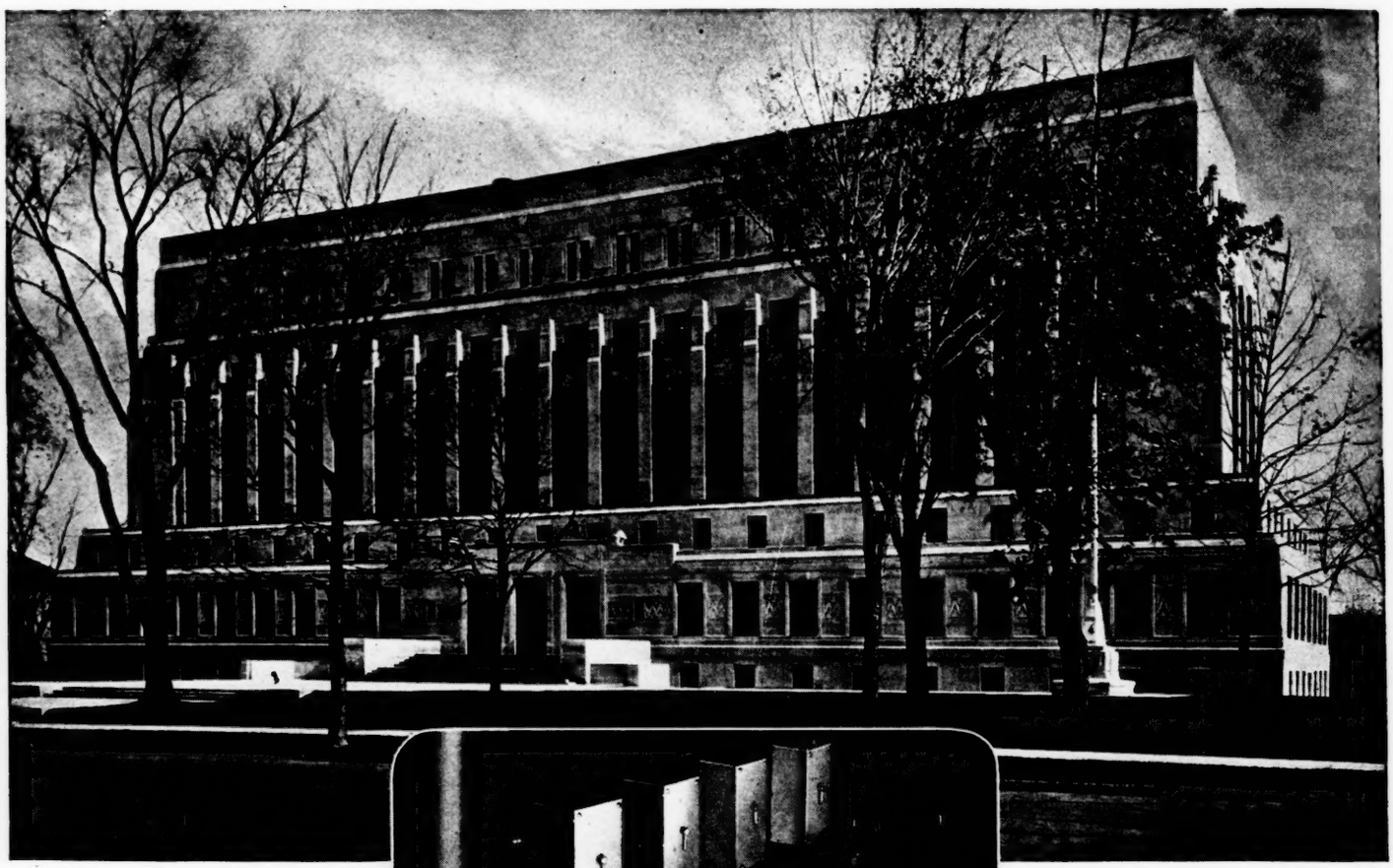
SHELL AND COIL MODELS FOR SMALLER CAPACITIES

On jobs from 1 ton up to 50 tons Acme shell and coil standard models are today serving efficiently on many hundreds of installations. Acme offers a complete line for all smaller-size requirements. Write for catalog No. 12.

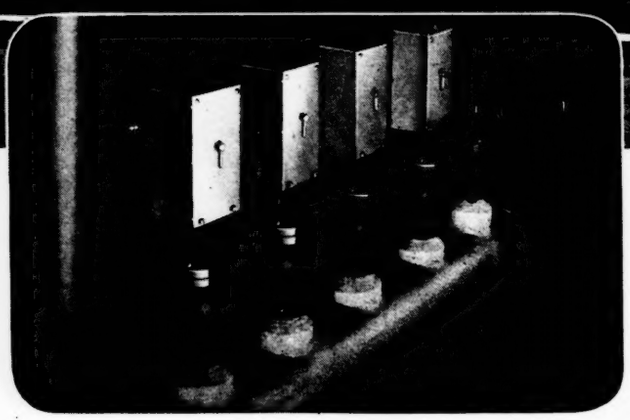
Evaporative Condensers
Ammonia Condensers
Freon Condensers
Dry-Ex Water Coolers
Flooded Water Coolers
Hi-Peak Water Coolers
Forced Convection Units
Pipe Coils
Heat Interchangers
Oil Separators
Liquid Receivers
Heat Exchangers

ACME PRODUCTS

Write for Catalog on any item.



The Sheboygan County Court House, Sheboygan, Wisconsin. B-C controls installed in 1936.



Four B-C Valves on blast coils as installed and in use today.

EIGHT YEARS USE . . . "NO SERVICE EXPENSE WHATSOEVER" WITH BARBER-COLMAN TEMPERATURE CONTROLS

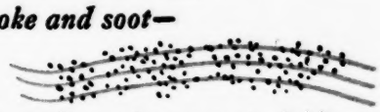
EIGHT years ago Barber-Colman motor-operated valves were installed in the steam coils of the blast system in this building. Controlled by a duct thermostat, they were arranged to admit steam to one or more of the four banks of coils automatically to maintain a uniform temperature ahead of the mixing chamber. In addition, other controls of the Barber-Colman System provided automatic means for mixing fresh and recirculated air to maintain desired ventilating system conditions. This installation is an excellent example of how Barber-Colman control equipment provides reliable service at minimum maintainance cost. Recently, a letter received from the building engineer stated that the Barber - Colman equipment had been "installed and in operation for eight years without any service expense whatsoever." Many other Barber-Colman Systems in buildings of all sizes are giving similar service. Consider this valuable feature of low maintenance cost when selecting an automatic temperature control system, to obtain durable, accurate, dependable operation.

BARBER-COLMAN COMPANY
1224 ROCK STREET • ROCKFORD, ILLINOIS

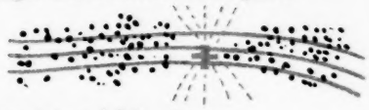
Precipitron KEEPS AIR FROM "SCRATCHING" SUPERFINISHED SURFACES

A NEW PRINCIPLE FOR CLEANING AIR

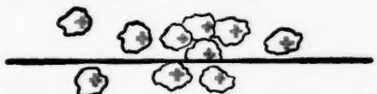
Dirt, smoke and soot—



passes through an electrostatic field



receives a positive (+) charge



and is drawn to a collection plate of opposite polarity (—)

where it remains until flushed down the drain.

Scratching superfinished surfaces means costly rejects. Air-borne dust and dirt can cancel the productive results of irreplaceable man-hours, increase costs and waste precious materials.

Precipitron* is your protection against this damage. This Westinghouse electronic method of cleaning air is the most efficient yet developed—90% more effective than mechanical methods. Precipitron removes foreign particles as small as 1/250,000 of an inch. Even tobacco smoke, most difficult of all air-borne matter to remove, is effectively captured on Precipitron collector plates.

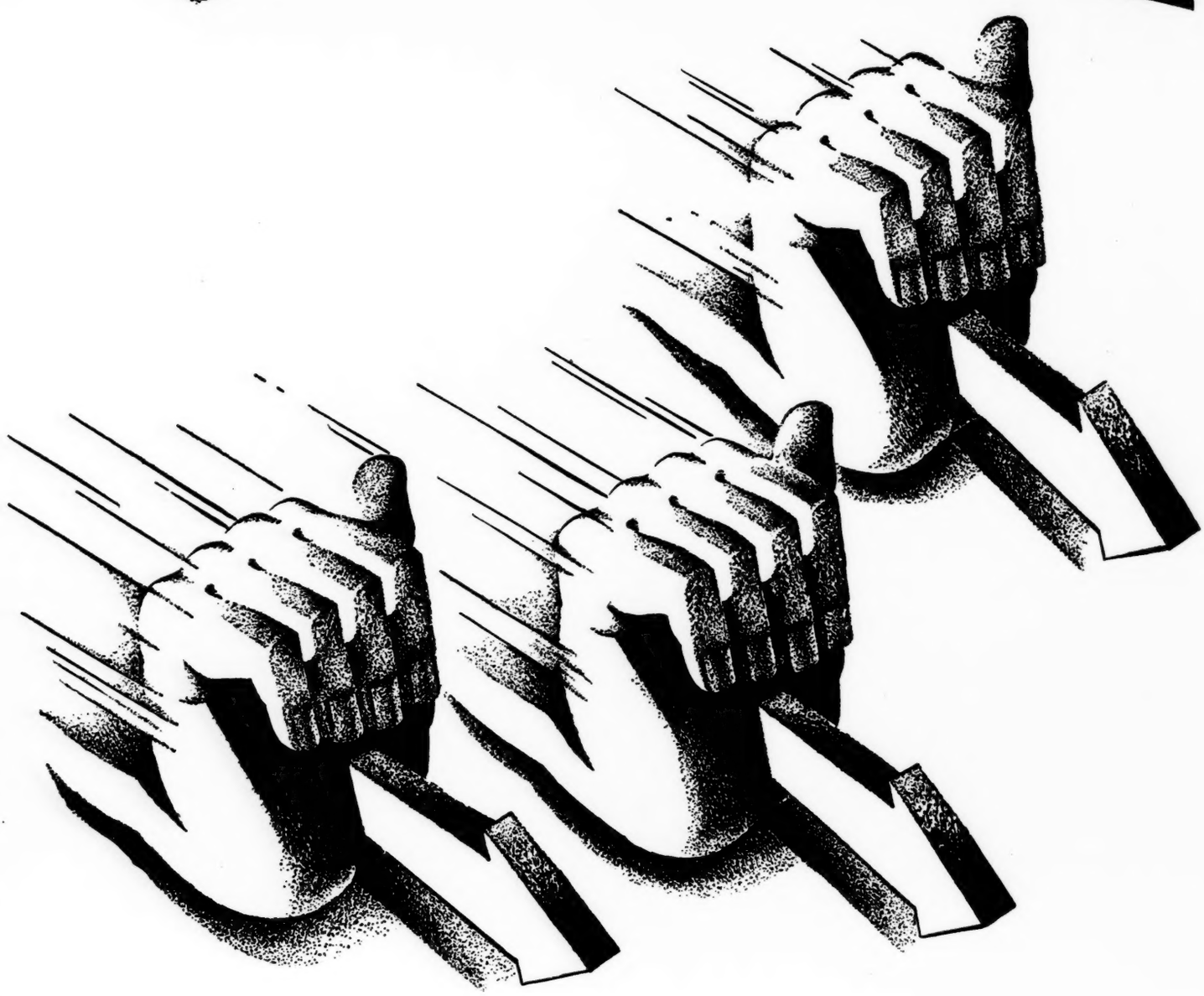
If protection for your precision work calls for *clean* air be sure to get all the facts about the Precipitron. Full details of its application and low-cost operation can be obtained from your nearest Westinghouse office. Or, write Westinghouse Electric & Manufacturing Co., Dept. 7-N, East Pittsburgh, Pa. J-04007

*Trade-mark registered in U. S. A.

Westinghouse Precipitron *the Electronic Air Cleaner*

PLANTS IN 25 CITIES OFFICES EVERYWHERE

THREE NEW PARTNERS . . . GOING



TERMINAL TOWER
CLEVELAND, OHIO

AHEAD WITH DRESSER

DRESSER INDUSTRIES now number ten.

Formerly, we were seven companies helping to bring basic services to the user more efficiently.

Our three new partners, each a specialist in its fields, both round out and broaden Dresser's scope of usefulness. This larger Dresser group can now serve industry and consumers with more products and greater experience.

The new Dresser members are bulwarked by an organization that assures their customers continued progress in product improvement, greater wherewithal for pioneering research and steady maintenance of service.

Dresser Industries, Inc., has progressed through the management principle of giving to alert, independent know-how an adequate backing and pooled resources. From these, each member draws teamed strength far greater than it could enjoy alone. The three new members of Dresser Industries, Inc., increase opportunities for mutual aid among the teammates, and at the same time, draw from the group advantages for those they serve.

MEMBER COMPANIES

Dresser Manufacturing Division
Bradford, Pa.

The Bryant Heater Co.
Cleveland, Ohio

Clark Bros. Co., Inc.
Olean, N. Y.

Pacific Pumps, Inc.
Huntington Park, Calif.

Bovaird & Seyfang Mfg. Co.
Bradford, Pa.

Dresser Mfg. Co., Ltd.
Toronto, Ont.

Van der Horst Corp. of America
Olean, N. Y. Cleveland, Ohio

PLUS

***International Derrick & Equipment Co.**
Columbus and Marietta, Ohio
Torrance, Calif. Beaumont, Texas

***Roots-Connersville Blower Corp.**
Connersville, Ind.

***Stacey Bros. Gas. Construction Co.**
Cincinnati, Ohio

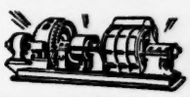
DRESSER Pipe couplings and repair devices for pipeline systems. Rings and forgings.

BRYANT Gas-fired boilers, winter air conditioners, furnaces, unit heaters and conversion burners for residential, commercial and industrial heating.

CLARK Engines and compressors for oil production and refining. Marine and stationary Diesel engines.

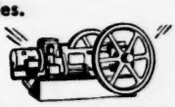
PACIFIC Hot-oil charging pumps; boiler-feed pumps; general-service pumps for the petroleum and other industries; oilwell plunger pumps; deep-well turbine pumps.

INTERNATIONAL DERRICK Oilwell pumping units, derricks and masts, drawworks, rotary tables and drilling units. Airport, communications and electric-power-line equipment and prefabricated steel buildings.



ROOTS-CONNERSVILLE Positive displacement and centrifugal blowers, exhausters, boosters and compressors. Air and liquid pumps and meters.

STACEY BROS. Storage holders, tanks and pressure vessels for the gas, oil, chemical and food industries.



BOVAIRD & SEYFANG Pumping engines, jacks, "powers", storage tanks and allied supplies and equipment for oilfields.

VAN DER HORST PORUS-KROME—a patented process of applying chromium lining on cylinder walls, piston rings and crankshafts—for longer wear.

DRESSER INDUSTRIES
INCORPORATED

300,000 Installed Tons

...SATISFACTORY RESULTS!

WHAT is your main consideration as an architect when you specify equipment for a building? We believe it is that the equipment will give your client satisfactory, trouble-free service.

That's why so many architects specify Carrier Centrifugal Refrigeration whenever plans call for large refrigeration requirements. Ever since the first Carrier Centrifugal Refrigerating Machine was installed in 1922, it has met the demands for cooling and refrigeration in many types of buildings. The Carrier record includes hundreds of successful installations, totalling 300,000 tons, which in actual performance have proved the many advantages of the Carrier Centrifugal Refrigerating Machine.

Carrier Centrifugal Refrigeration . . . whether used to chill any liquid directly or to condense any vapor at any temperature level down to minus 130° F. . . . can be depended on to provide trouble-free, quiet, vibrationless service, year in and year out . . . 24 hours a day if necessary.

Installation can be made in any part of the building — either in the basement or on an upper floor. It is readily adaptable to direct turbine drive, as well as to all types of motor drives. In many cases it has been used with especially satisfactory results in conjunction with turbine drive using low pressure steam from the heating plant. Economy of power and refrigerant and low maintenance cost are other benefits of Carrier Centrifugal Refrigeration.

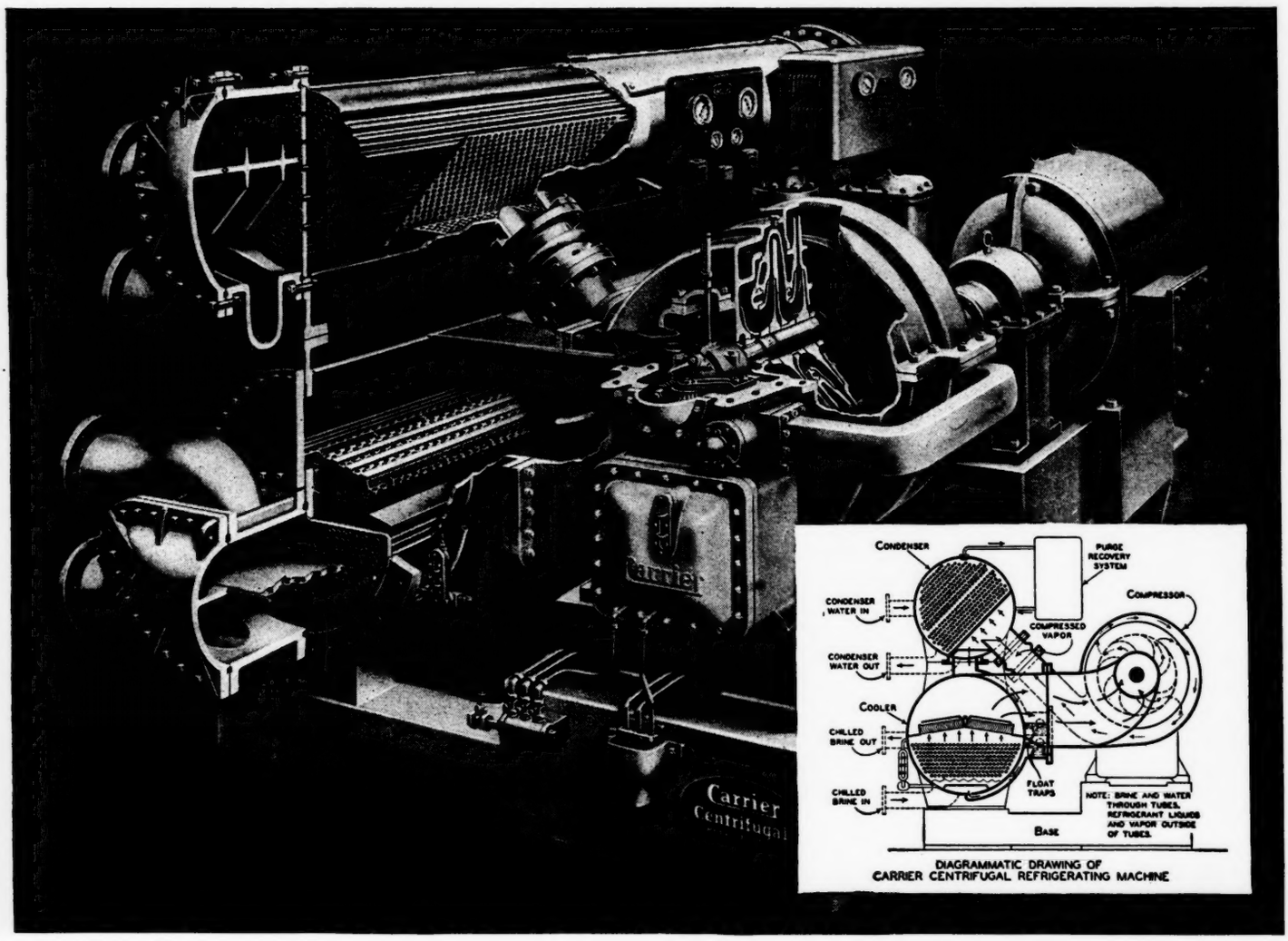
Made in a wide range of sizes in capacities up to 1200 tons, Carrier Centrifugal Refrigerating Machines are providing cooling in the tremendous tonnages needed in many of the world's largest buildings including the new Pentagon Building and Hotel Statler in Washington.

Carrier engineers will be glad to discuss now the use of Carrier Centrifugal Refrigeration for any of your postwar plans.

CARRIER CORPORATION • Syracuse 1, N. Y.

Carrier ARMY E NAVY

CENTRIFUGAL · REFRIGERATION



DIAGRAMMATIC DRAWING OF CARRIER CENTRIFUGAL REFRIGERATING MACHINE

WHAT THE HEART IS TO LIFE

THE SWITCH IS TO A CONTROL

In Either Case, When One Fails All Else Ceases To Function

As long as the blood stream is permitted to flow through the heart, the human machine goes on, fulfilling its destiny. Likewise, as long as the electrical current is permitted to flow through the switch the control fulfils its designed purpose in whatever automatic heating or industrial application it may be used with.

The relative importance of a switch is sometimes overlooked, especially in an automatic control. In the event of a switch failure, as in the case of a boiler pressure or temperature limit control, as well as other important applications, the failure may prove hazardous and costly. That is why from the very beginning, Mercoid Automatic Controls were equipped exclusively with the now famous hermetically sealed Mercoid mercury switches, known and used the world over. They provide an electrical contact designed for millions of perfect operations —one reason why Mercoid Controls are noted for their long life and better performance. Mercoid switches are immune to dust, dirt, moisture or corrosion. They are not subject to open arcing, pitting or sticking of the contacting surfaces. That is the reason why Mercoid Controls are following the Army in some of the far outposts where adverse and extreme humid weather conditions exist.

There are many other important features incorporated in Mercoid Controls, but in the meantime, remember the all-important Mercoid Switch—the unfailing heart of Mercoid Controls.

THE MERCOID CORPORATION, 4221 BELMONT AVENUE, CHICAGO 41, ILLINOIS

"WHAT'S THE ANSWER IN DOLLARS and CENTS

...if we modernize our boiler plant now?"

YOU enjoy immediate savings in fuel consumption, plus a substantial step-up in steam production, when you modernize with TODD burners.

Hundreds of plants have already modernized costly, inefficient boiler plants with TODD oil and gas burning equipment. *They report fuel savings up to 10% and more, with corresponding power increases.*

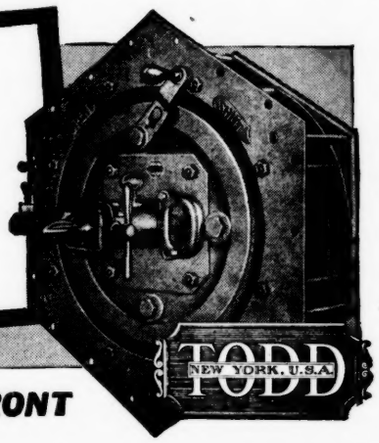
Operating economies like these are not unusual. For the over-all efficiency of the modern TODD burner, reflecting 30 years of sound engineering achievement, means *steam production at minimum cost*—a dollars-and-cents reason why NOW IS THE TIME TO MODERNIZE WITH TODD.

TODD combustion engineers are specialists in the modernization of industrial and commercial boiler rooms of all types. Why not call on them today . . . for an impartial survey of *your* plant . . . for suggestions, specifications, estimates. Their services are available at any time, without obligation.

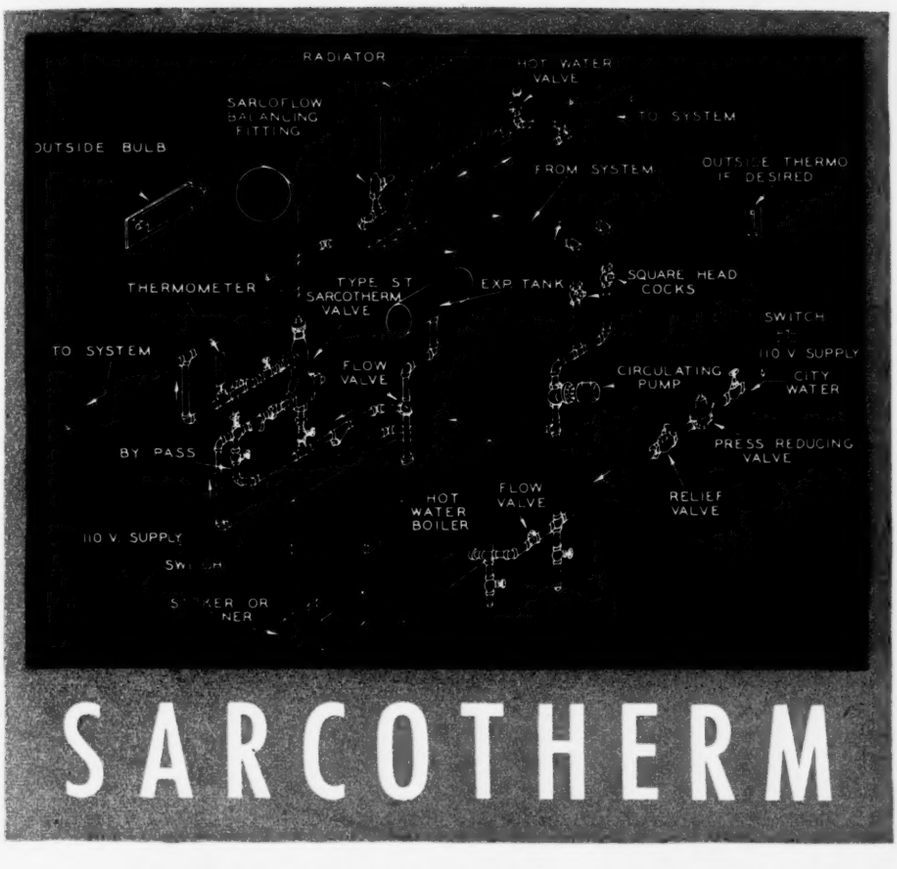
ARMY E NAVY

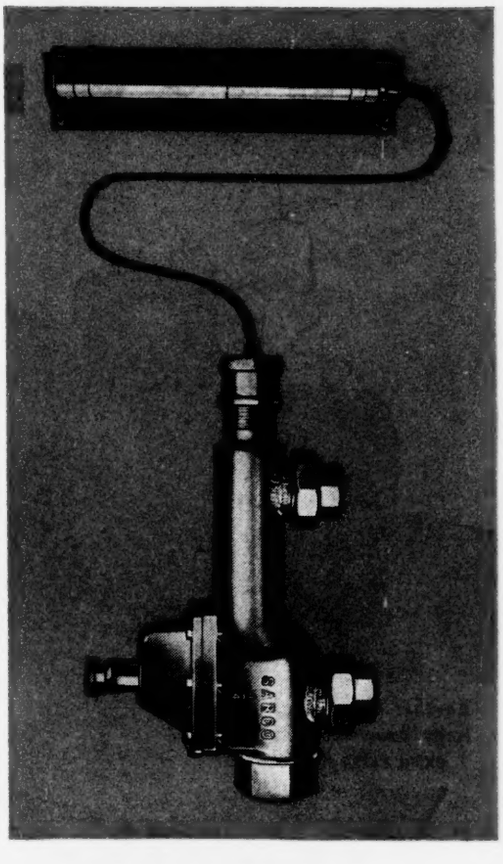
COMBUSTION EQUIPMENT DIVISION
TODD SHIPYARDS CORPORATION
601 West 26th Street, New York 1, N. Y.

NEW YORK, BROOKLYN, ROCHESTER, HOBOKEN, NEWARK, BARBER, N. J., PHILADELPHIA, SO. PORTLAND, ME., BOSTON, SPRINGFIELD, MASS., BALTIMORE, WASHINGTON, CHICAGO, GRAND RAPIDS, TAMPA, GALVESTON, HOUSTON, MOBILE, NEW ORLEANS, LOS ANGELES, SAN FRANCISCO, SEATTLE, TACOMA, MONTREAL, TORONTO, BUENOS AIRES, LONDON



ON THE FIRING LINE OF AMERICA'S WAR PRODUCTION FRONT





HOT WATER HEATING CONTROL

Provides

CONTINUOUS CIRCULATION CONTROLLED BY OUTSIDE TEMPERATURE

on new or old systems for all types of buildings.

•

Ideal control for Radiant Heating.

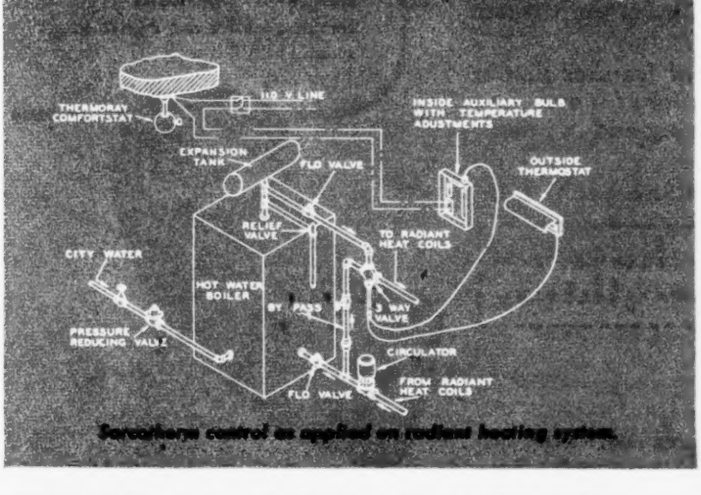
When you can tell the owner that "the best costs less" your advice will be heeded.

Sarcotherm is best because it is a simple, sturdy valve that constantly recirculates unused heat with modulated control and anticipation of room temperature fluctuations. No on and off, no "cold seventies."

It costs less because it is relatively inexpensive to install, permits higher water temperatures, smaller radiators and pipes, with less strain on the boilers. It also assures large fuel savings by preventing overheating in mild weather.

Ask for catalog No. 1.

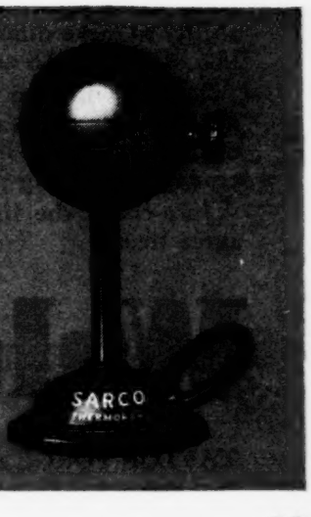
SARCOTHERM CONTROLS, INC., 222 N. Bank Drive, Chicago 54, Ill.



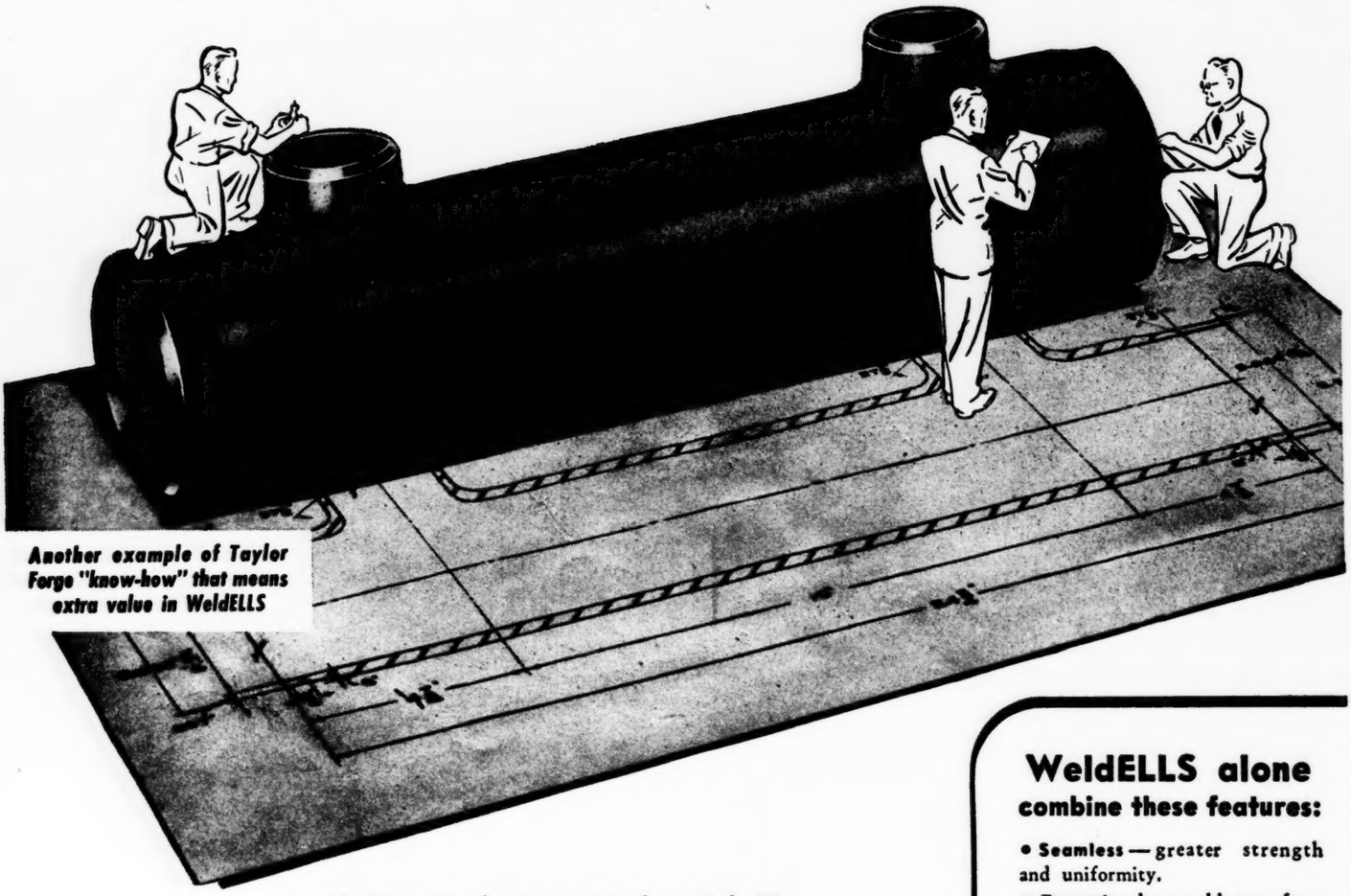
Sarcotherm control as applied on radiant heating system.

When Sarcotherm is used to control a radiant heating system, the thermoray is substituted for the room thermostat.

It is sensitive to both air temperature and radiant rays, and is thus responsive to the heat loss conditions affecting the human body.



FUSSY PEOPLE, THESE!



Another example of Taylor Forge "know-how" that means extra value in WeldELLS

★ *Two Taylor Forge Carbon-Moly Tees with a 5½" nipple welded between them would have provided an assembly with the same overall dimensions as the special "tandem outlet" 5x5x2½x2½" seamless carbon-moly tee pictured here. But this was a particularly "fussy" job with so much at stake that the engineers wanted this exact fitting.*

Quite naturally, this job wound up at Taylor Forge; for engineers throughout America have learned that the meticulous jobs—those which call for unusual skill and knowledge in the forming of hot metals—are expertly handled here.

MOST people know of Taylor Forge's reputation for doing the unusual —sometimes even the "impossible". But the important thing to recognize is that the very same factors which built this reputation also provide many extra values in our standard, stock welding fittings . . . that this ability to make difficult "specials" is reflected in the design of our regular line of WeldELLS and other Taylor Forge fittings.

That is why you find in WeldELLS a combination of features that is not incorporated in any other make. There are sound reasons for everyone of them, and the overall result is a stronger, longer lasting and . . . more *economical* piping job.

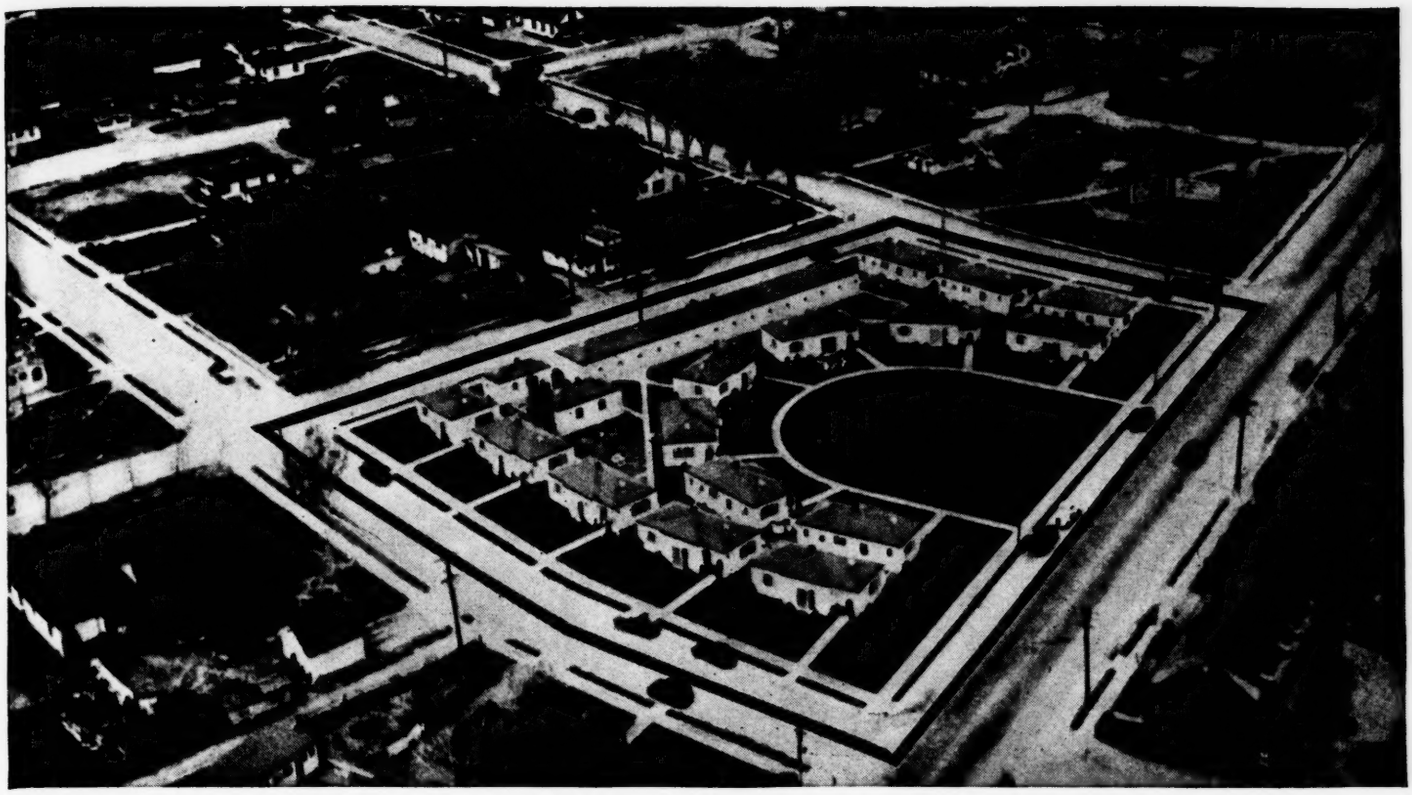
Just check the list of features opposite and we believe you'll fully agree that

WeldELLS have everything

WeldELLS alone
combine these features:

- **Seamless** — greater strength and uniformity.
- **Tangents**—keep weld away from zone of highest stress—simplify lining up.
- **Precision quarter-marked ends**—simplify layout and help insure accuracy.
- **Selective reinforcement** — provides uniform strength.
- **Permanent and complete identification marking**—saves time and eliminates errors in shop and field.
- **Wall thickness never less than specification minimum**—assures full strength and long life.
- **Machine tool beveled ends**—provides best welding surface and accurate bevel and land.
- **The most complete line of Welding Fittings and Forged Steel Flanges in the World** — insures complete service and undivided responsibility.

TAYLOR FORGE & PIPE WORKS, General Offices & Works: Chicago, P. O. Box 485
New York Office: 50 Church Street • Philadelphia Office: Broad Street Station Bldg.



$3.44 PER MONTH PER APARTMENT
FOR HEAT AND HOT WATER!

This housing project illustrates clearly why the B & G Monoflo System is *the preferred heating system.* The amazing economy of operation revealed by the following data is not unusual—it is being duplicated in thousands of large and small installations the country over.

LOCATION: Reno, Nevada

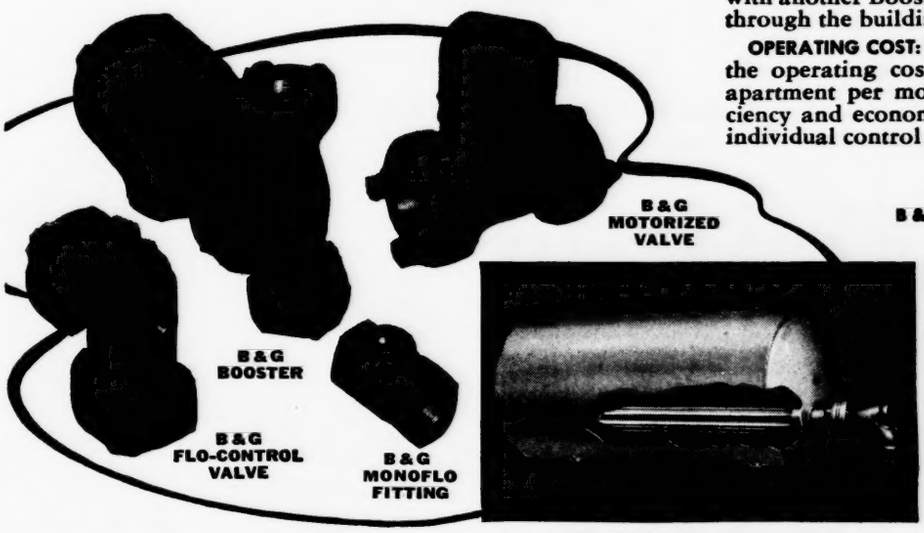
OWNER: Mr. Roland Giroux

SIZE: 16 five-room apartments on a 1½ acre tract

HEATING: B & G Monoflo System, supplied from a central heating plant, with two main circuits, each equipped with a 3″ B & G Booster Pump. The heating of each apartment is individually controlled by a thermostat operating a B & G Motorized Valve. Any thermostat calling for heat opens the Valve and starts the Booster in its respective circuit. Four boilers are installed, with three carrying the heating load and one used as a spare.

HOT WATER: Hot water for household use is furnished by a B & G Unitem Tank Heater. Boiler water is circulated through the heater coil by a bronze-bodied B & G Booster, with another Booster used to circulate the domestic water through the buildings.

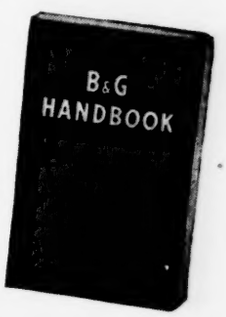
OPERATING COST: Based on a nine month heating season, the operating cost of this system averages $3.44 per apartment per month—an outstanding example of efficiency and economy. Tenant comfort is assured by the individual control of each apartment's heating.



B&G UNITEM TANK HEATER

B&G HANDBOOK TELLS HOW TO DO IT

The design and installation of Forced Hot Water Heating Systems and Service Water Heating Systems are fully covered in this 262 page, handsomely bound manual. Illustrated with hundreds of diagrams for easy understanding — packed with tables you need daily. For your copy, write today on your business stationery.



B&G MONOFLO SYSTEM

BELL & GOSSETT COMPANY, MORTON GROVE, ILLINOIS

Canadian Licensee: S. A. Armstrong Ltd., 115 Dupont St., Toronto

NEXT ON THE RATION LIST?

It's not quite that serious yet—BUT—

A critical water shortage *does* face many industrial plants today. Even where water supplies are not overtaxed, sewers often are—choked with wasted cooling water—and wasted money!

Evaporative Condensers can end all this waste at once. They give you *20 gallons' worth of cooling from every gallon of water*—by using it over and over until it evaporates.

"MARLO MEANS HEAT TRANSFER EQUIPMENT"

MARLO makes a complete range of sizes for every refrigerant, from 5 to 100 ton capacity. Long, low-cost service is assured by: Sturdy Sectional, Corrosion-Proofed Construction • Marlo Single-Motor "Unidrive" • Self-Aligning Bearings • All Prime Surface Coils (after the war).

May we send our descriptive bulletin?

MARLO
EVAPORATIVE CONDENSERS

Ball-Bonded Blast Coils—Cooling and Heating • Air Conditioning and Refrigeration Apparatus • Industrial Blower Units • Unit Coolers Evaporative Condensers and Coolers • Low Temperature Apparatus

MARLO COIL COMPANY

ST. LOUIS 10, MISSOURI

The MOST *of* HEATING COMFORT *for the* LEAST AMOUNT OF FUEL AND MANPOWER

DUNHAM Differential HEATING

COMFORT heating-levels remain constant, with Dunham Differential Heating, regardless of fluctuating outdoor temperatures and weather conditions or building exposures.

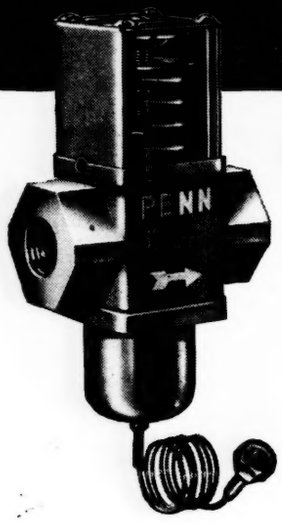
The maximum of comfort is given with a minimum of fuel consumption and a minimum of manual supervision. Regardless of size or number of buildings in a project, each building, or zone of a building, will be properly heated with an economy of operation far beyond the capabilities of any pressure steam heating system.

May we send you Brochure 632 entitled "High Altitude Heating"? It explains, in non-technical language, the method and advantages of sub-atmospheric steam heating.

C. A. DUNHAM COMPANY
450 EAST OHIO ST., CHICAGO 11, ILL.
Toronto, Canada London, England

You can't see them

but they're here!



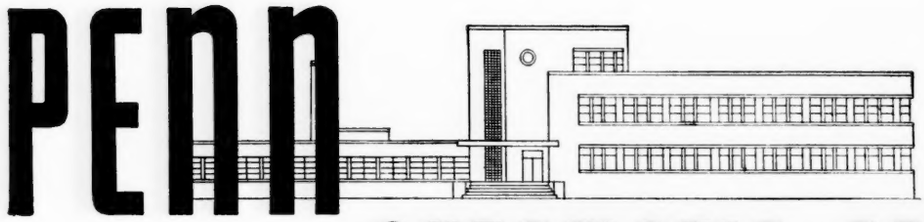
the DESTRUCTIVE THREE that cripple water valves

Wherever you find water, there you'll find the Destructive Three—*Sedimentation, Corrosion* and *Rust.* They've crippled many a water valve, these three . . . but not the PENN 246! That's because this new water regulator is so designed that *no sliding parts touch the water.*

Thus PENN has put a stop to sticking valve seats, rusty range springs and the abrasive desposits that cause early wear.

Water hammer is gone, too . . . yet the PENN 246 is extremely sensitive to changes in refrigerant head pressure. It's available in two types—flanged and threaded—both of which allow for *manual flushing.*

Full details on this new PENN Water Regulator are available without cost in your copy of Bulletin R-1986. Write *Penn Electric Switch Co., Goshen, Ind.* Export Division: 13 E. 40th Street, New York 16, U.S.A. In Canada: Powerlite Devices, Ltd., Toronto, Ont.



AUTOMATIC CONTROLS

FOR HEATING, REFRIGERATION, AIR CONDITIONING, ENGINES, PUMPS AND AIR COMPRESSORS

SUPER-CLEAN AIR!

AAF Multi-Duty filters clean themselves as they clean the air. Fully automatic. Send for Bulletin No. 241A.

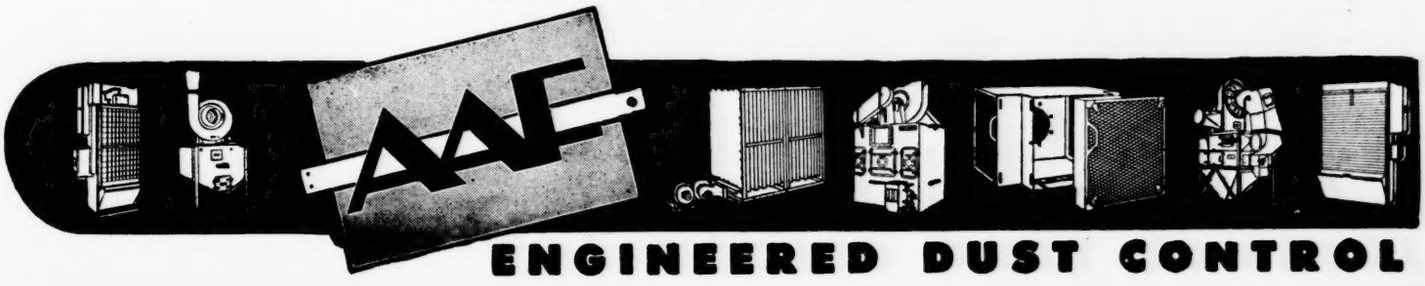
An era of competition such as American industry has never before experienced will break like a bomb shell when peace is made, and manufacturers return to producing civilian consumer goods. To be prepared to operate profitably in this new economy calls for careful planning TODAY – careful consideration of all the factors that might result in lowering manufacturing costs.

Industry has long since recognized the need for adequate dust control and has learned thru its wartime experience that in the post-peace era, dust control will be a factor of major importance. And feather-duster methods won't do – only engineered dust control systems designed by experienced dust engineers can be expected to do a satisfactory job.

AAF has the facilities TODAY to help you work out your tomorrow's dust control system. There is no obligation involved in asking for help. Let us send you "AAF in Industry"– a booklet which describes the full line of AAF equipment–preliminary to discussing your needs with one of our engineers.

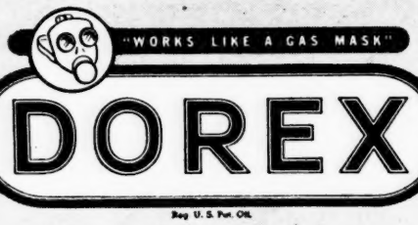
AMERICAN AIR FILTER CO., INC., 294 Central Ave., Louisville 8, Ky.

In Canada: Darling Bros., Ltd., Montreal, P.Q.



ENGINEERED DUST CONTROL

NEW ECONOMIES FOR AIR CONDITIONING



through DOREX

Reg U. S. Pat. Off.

AIR RECOVERY

AIR conditioning systems can now be operated more efficiently and economically through the use of DOREX Air Recovery Units.

DOREX Activated Carbon Adsorbers recover used air by *extracting** odorous, gaseous and vaporous impurities from it, thus providing these major economies:

★ *Conditioned* air that has been used is converted and re-circulated. The volume of *unconditioned* outside air is thereby kept to a minimum.

★ The required cooling or heating capacity of a proposed conditioning system is decreased.

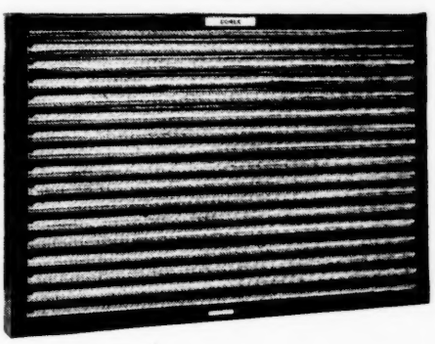
★ Existing air conditioning systems can serve larger spaces, take on increased loads *without* additional equipment and *without* more fuel or energy consumption.

**DOREX does not mask impurities—it removes them.*

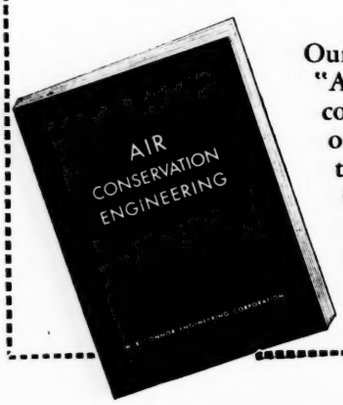
DOREX TYPE H CANISTER UNIT

Consists of multiple, removable, perforated, activated carbon filled canisters so arranged that all air passes uniformly through the granular carbon and all air-entrained gaseous and vaporous impurities are extracted.

DOREX TYPE G PANEL UNIT



Consists of multiple, closely spaced, perforated carbon filled tubes set in standard removable frames and so arranged that a predetermined portion of the air is decontaminated.



Our recently published textbook "Air Conservation Engineering" contains a comprehensive study of Air Recovery and its application to Air Conditioning. Copies are $2.00 each. Complimentary copies available to recognized engineers upon written request.

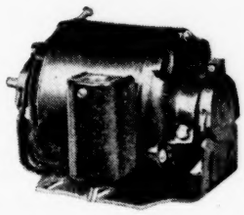
DOREX AIR RECOVERY EQUIPMENT

is designed to expose maximum absorbing surface with minimum air resistance. Low cost carbon reactivation service insures low maintenance.

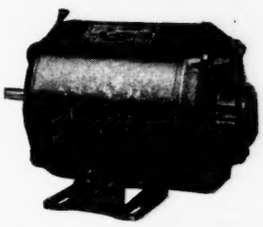
For information and quotations on DOREX AIR RECOVERY call nearest District Representative or write to Dept. E

W. B. CONNOR ENGINEERING CORPORATION

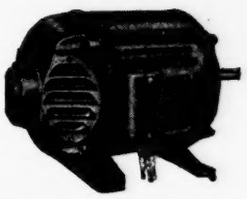
114 EAST 32nd STREET — WB CONNOR ENGINEERING CORP — **NEW YORK 16, N. Y.**



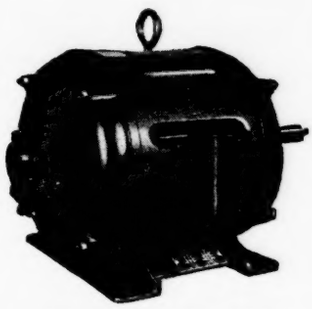
WAGNER SHADED-POLE MOTORS. For direct-connected propeller and centrifugal-fan applications requiring very small horsepower, and low starting-torque.



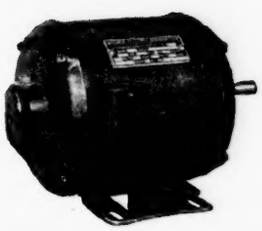
WAGNER REPULSION-START-INDUCTION MOTORS. Ideal for driving condensing units, pumps, and blowers.



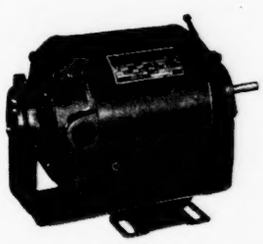
WAGNER DIRECT-CURRENT MOTORS are built to meet direct-current drive requirements.



WAGNER OPEN-TYPE SQUIRREL-CAGE MOTORS are used on blowers, fans, compressors, pumps, etc.



WAGNER SPLIT-PHASE MOTORS are applied to unit-heaters, oil-burners, fans and blowers and many other types of equipment.



WAGNER TOTALLY-ENCLOSED MOTORS. Particularly adaptable for unit-heater applications.

WAGNER CAPACITOR-START INDUCTION-RUN MOTORS are particularly adaptable to refrigerators, stokers, and other household appliances.

MOTORS
are but one of several WAGNER PRODUCTS serving industry.

Other **WAGNER PRODUCTS:**

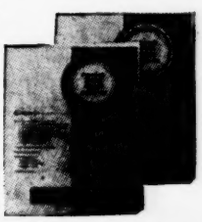
AIR BRAKES
•
BRAKE LINING
•
HYDRAULIC BRAKES
•
INDUSTRIAL BRAKES
•
INDUSTRIAL BRAKE CONTROLS
•
TACHOGRAPH (Recording Speedometer)
•
TRANSFORMERS

Consider Wagner MOTORS

. . . On all Postwar Refrigeration and Air Conditioning Equipment

Foresighted manufacturers are now planning refrigeration and air-conditioning equipment for postwar markets. Dependable motor power must be given careful consideration, and Wagner engineers have designed motors that will do an economical and dependable job on postwar equipment.

The skill and facilities Wagner has gained in years of producing good dependable motors for air-conditioning and refrigeration application are available to you in solving the problems involved in planning and designing your equipment to meet postwar demands.



M44-20

Send for these **BULLETINS**

Bulletins MU-182 and MU-183 describe and illustrate the complete line of Wagner motors. Bulletins MU-7B and MU-30B give complete service instructions.

Wagner Electric Corporation

ESTABLISHED 1891

6463 Plymouth Avenue, St. Louis 14, Mo., U. S. A.

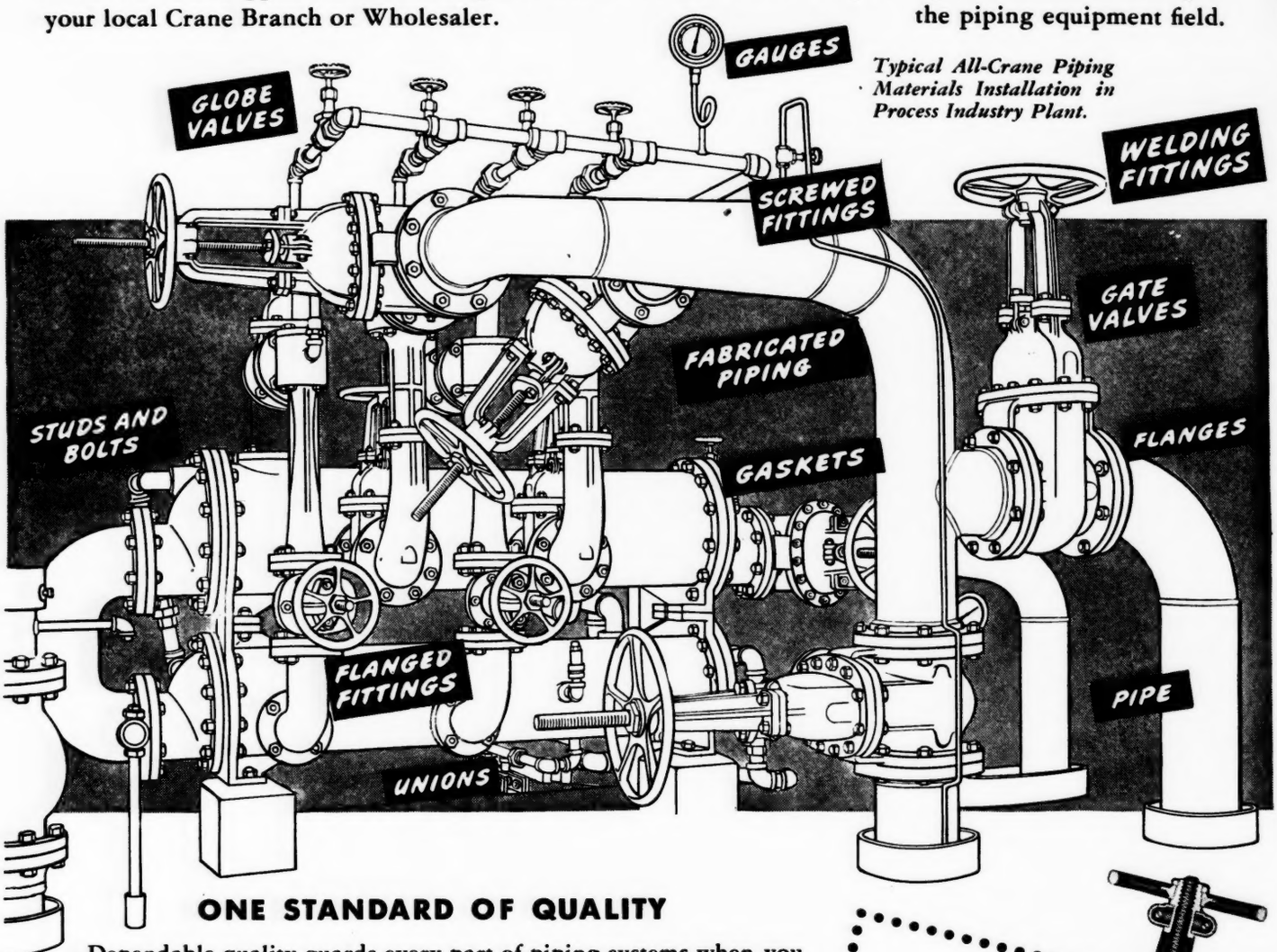
ELECTRICAL AND AUTOMOTIVE PRODUCTS

Piping Materials for Any Need ...Crane Can Supply Them

ONE SOURCE OF SUPPLY . . . ONE RESPONSIBILITY FOR ALL EQUIPMENT

The easiest way to dispose of piping supply problems is to put them up to Crane. Doing that gives you the world's greatest selection of equipment for every service—power or processing systems, high or low working pressures. All your needs of valves, fittings, pipe, fabricated assemblies and piping accessories are supplied from one single source—your local Crane Branch or Wholesaler.

Now when you are trying to catch up with deferred maintenance, Crane *complete* piping materials service is a big advantage. From ordering to installation, every step of the job is simplified. And while one responsibility for materials helps assure the best installations, you are also getting full benefit of Crane Co.'s 89-year experience and leadership in the piping equipment field.



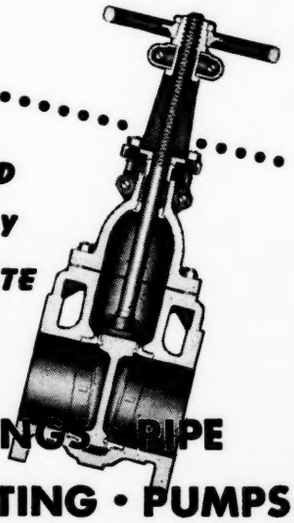
Typical All-Crane Piping Materials Installation in Process Industry Plant.

ONE STANDARD OF QUALITY

Dependable quality guards every part of piping systems when you specify Crane materials throughout. Such quality is exemplified by Crane Iron Body Wedge Gate Valves. Strong body sections resist severest strains. Straight-through ports permit unrestricted flow. A deep stuffing box lengthens packing life. Long guides keep disc travel true, while the finest design in every part assures long life and smooth, trouble-free service.

Crane Co., General Offices: 836 S. Michigan, Chicago 5, Ill.

Branches and Wholesalers Serving All Industrial Areas



STANDARD IRON BODY WEDGE GATE VALVES

CRANE

VALVES • FITTINGS • PIPE
PLUMBING • HEATING • PUMPS

© McDONNELL & MILLER

The BEST time to protect a boiler is *yesterday!*

THE only protection of life and property that means anything is the kind that's *in* and *working*. Tomorrow may be too late!

People respect this when it comes to life insurance, or even casualty insurance—not because they think their house will burn tomorrow, but because they would feel mighty uneasy if their fire insurance lapsed for even a single day.

Yet there are still thousands of boiler owners who are gambling on tomorrow and many tomorrows. Not many of them are the kind of people who knowingly take chances. They are simply people who haven't been made to realize that any minute of any day low water can cost them many times more than the boiler water feeder or low water fuel cut-off that would have prevented it.

It is your opportunity—and, in a sense, your duty—to show them that the only sure way to protect a boiler is to equip it with a McDonnell Boiler Water Feeder *right now*.

Explain why a boiler feeder is needed. Show how a hundred and one small and unnoticed things like spurting air valves, trapped returns, blown fuses in condensation pump circuits, or foaming and priming, can cause low water. Show them why a McDonnell Boiler Water Feeder safeguards their boiler day and night—feeds water as needed—eliminates the danger of opening up a big stream of cold water into a hot boiler—stops over-filling.

Tell the story to every owner of a residence, apartment building, office building, store building, theatre building, laundry, bakery—anyone, anywhere, who has a steam boiler. The best time to protect a boiler is "yesterday"—so do it now.

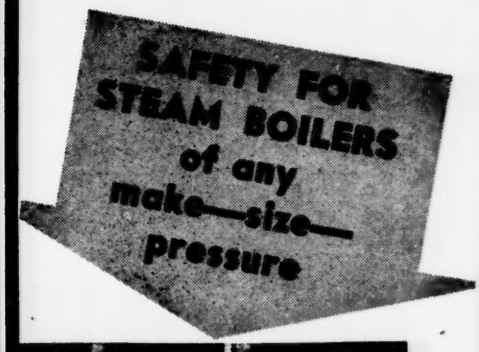
• Write for sales kit covering all the facts you need to sell and install McDonnell products.

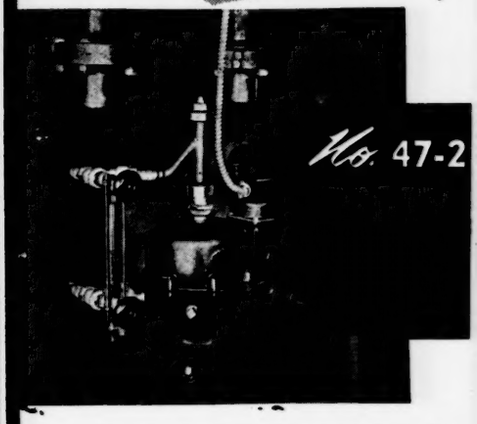
McDONNELL & MILLER, 1313 WRIGLEY BLDG., CHICAGO

Doing One SAFETY *Thing Well*

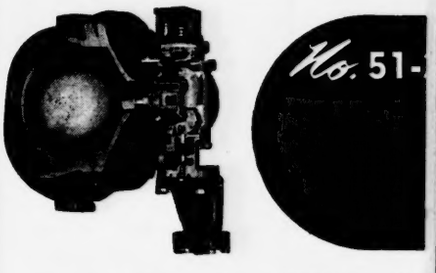
McDONNELL

BOILER FEEDERS AND LOW WATER CUT-OFFS





• For the boilers below 5000 sq. ft. maximum steam pressure, 25 lbs. Use the No. 47-2 for automatically fired boilers—No. 47 for hand-fired boilers—No. 147 or 147-2 for bakery and other process boilers.

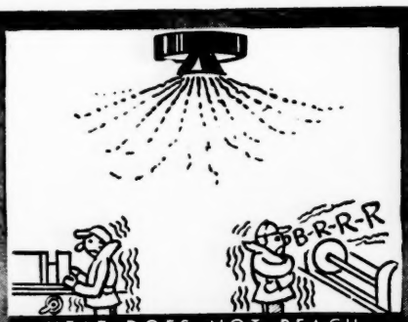


• For boilers above 5000 sq. ft. maximum steam pressure, 35 lbs. Use the No. 51-2 for automatically fired boilers—No. 51 for hand fired boilers—No. 53 or 53-2 for the boilers with pressures up to 75 lbs.

• For cut-off needs of all automatically fired boilers with pressures up to 25 lbs.
The next best thing to a feeder-cut-off combination.

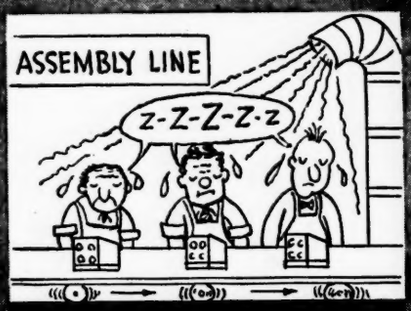
Your jobber stocks them

• For the high pressure boilers
There's a real opportunity today to sel the No. 150 as a cut-off, pump control alarm or for any combination of these functions in plants with steam pressure up to 150 lbs.

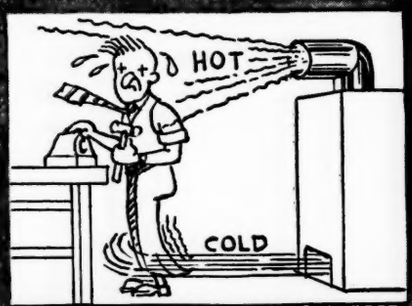


HEAT DOES NOT REACH WORKING ZONE

UNCOMFORTABLE RADIANT HEAT



SICKENING BLASTS OF HOT AIR

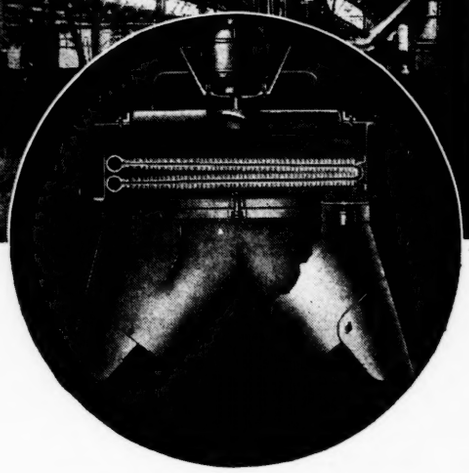


COLD INTAKE DRAFTS ON FEET
HOT DRAFTS ON THE HEAD

SOME WORKERS TOO HOT WHILE OTHERS ARE TOO COLD

Were You annoyed by heating complaints last Winter?

(Above) Installation of 63 Wing Revolving Unit Heaters in Plant of Automotive Appliance Manufacturer



Cross-sectional view of WING Revolving Unit Heater, showing Motor, Fan, Heating Element and Revolving Discharge Outlets.

The objectionable features of heating systems like those cartooned at the left are the cause of endless complaints.

WING *Revolving* HEATERS

ELIMINATE HOT SPOTS AND COLD SPOTS

Located at roof or ceiling, they revolve slowly, projecting the heated air to the working level in moving streams which sweep slowly through 360 degrees, covering successively every direction instead of constantly in some one direction. The gentle air motion and the thorough coverage bring a sensation of fresh, live, invigorating warmth to workers. **And in the Summer, with the steam turned off, they create a delightful cooling effect that is equally effective in stimulating production.**

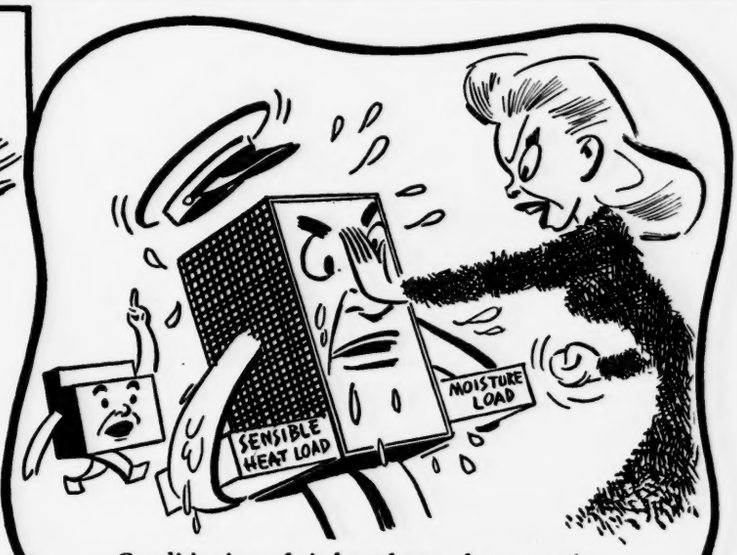
Write for Bulletin HR-3

L. J. Wing Mfg. Co., 158 W. 14th St., New York 11, N.Y.

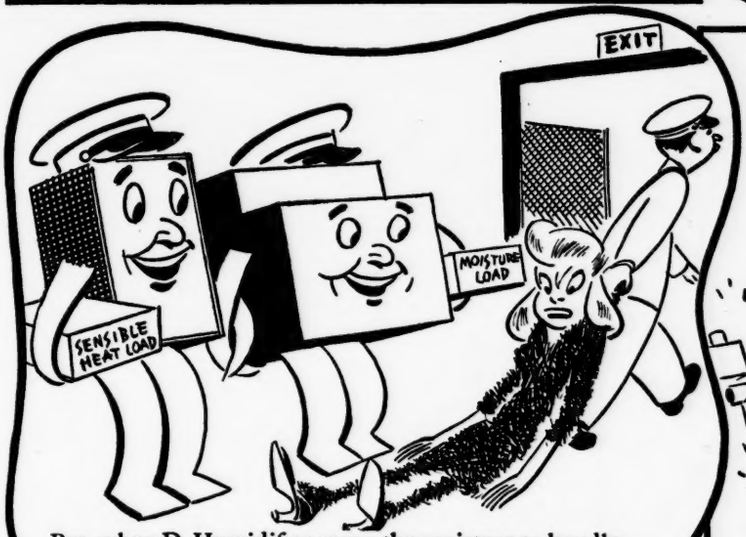
Factories: Newark, N. J. Montreal, Canada

KAY ROZION GETS THE GATE

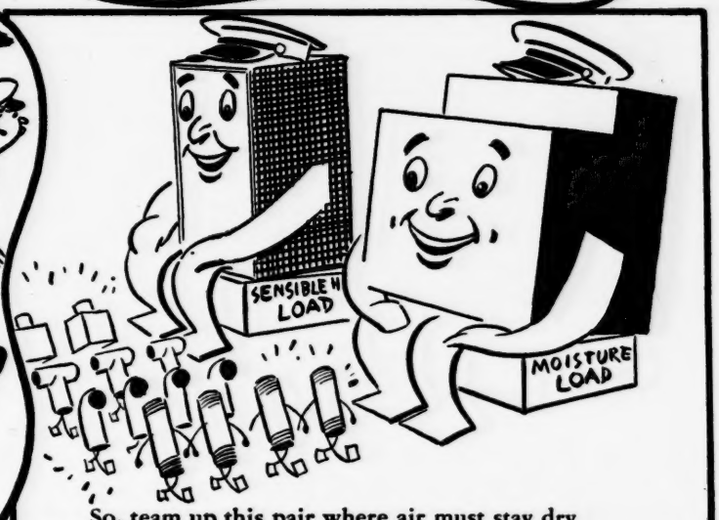
The touch of Kay Rozion has spoiled parts galore
Left them rusty, scaly and useless for war



Conditioning of air kept her under control
Till apt Johnny Coil had to play "double role"



But, when D. Humidifier came, the moisture to handle
'Twas the end of that pesky and troublesome vandal



So, team up this pair where air must stay dry
And to vixen Kay Rozion say forever, good-bye

Corrosion control is more positive and effective when your air conditioning system includes a Bryant Silica Gel Dehumidifier. This unit—now applied to corrosion control in plants such as Kollsman Instrument Company, Liquidometer Company, Wright Aeronautical Corporation and Elgin Watch Company—helps maintain optimum conditions of temperature and humidity, regardless of variation in sensible and latent heat load.

USE

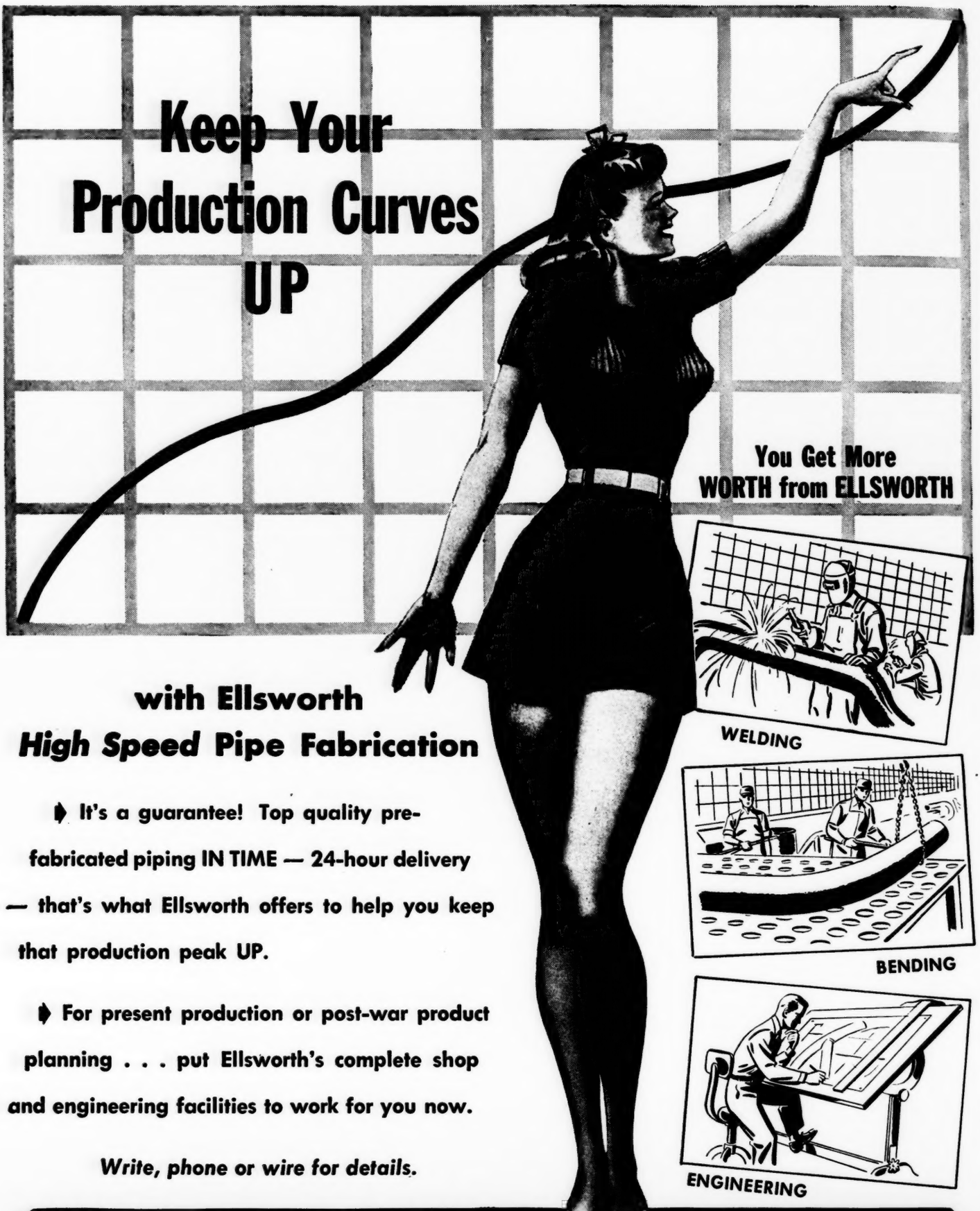
bryant

Silica Gel DEHUMIDIFIERS

FOR INDEPENDENT MOISTURE REMOVAL

WRITE today for this helpful book. Address the Bryant Heater Company, 17825 St. Clair Ave., Cleveland 10, Ohio. *One of the Dresser Industries.*

Keep Your Production Curves UP



You Get More WORTH from ELLSWORTH

WELDING

BENDING

ENGINEERING

with Ellsworth *High Speed* Pipe Fabrication

➧ It's a guarantee! Top quality pre-fabricated piping IN TIME — 24-hour delivery — that's what Ellsworth offers to help you keep that production peak UP.

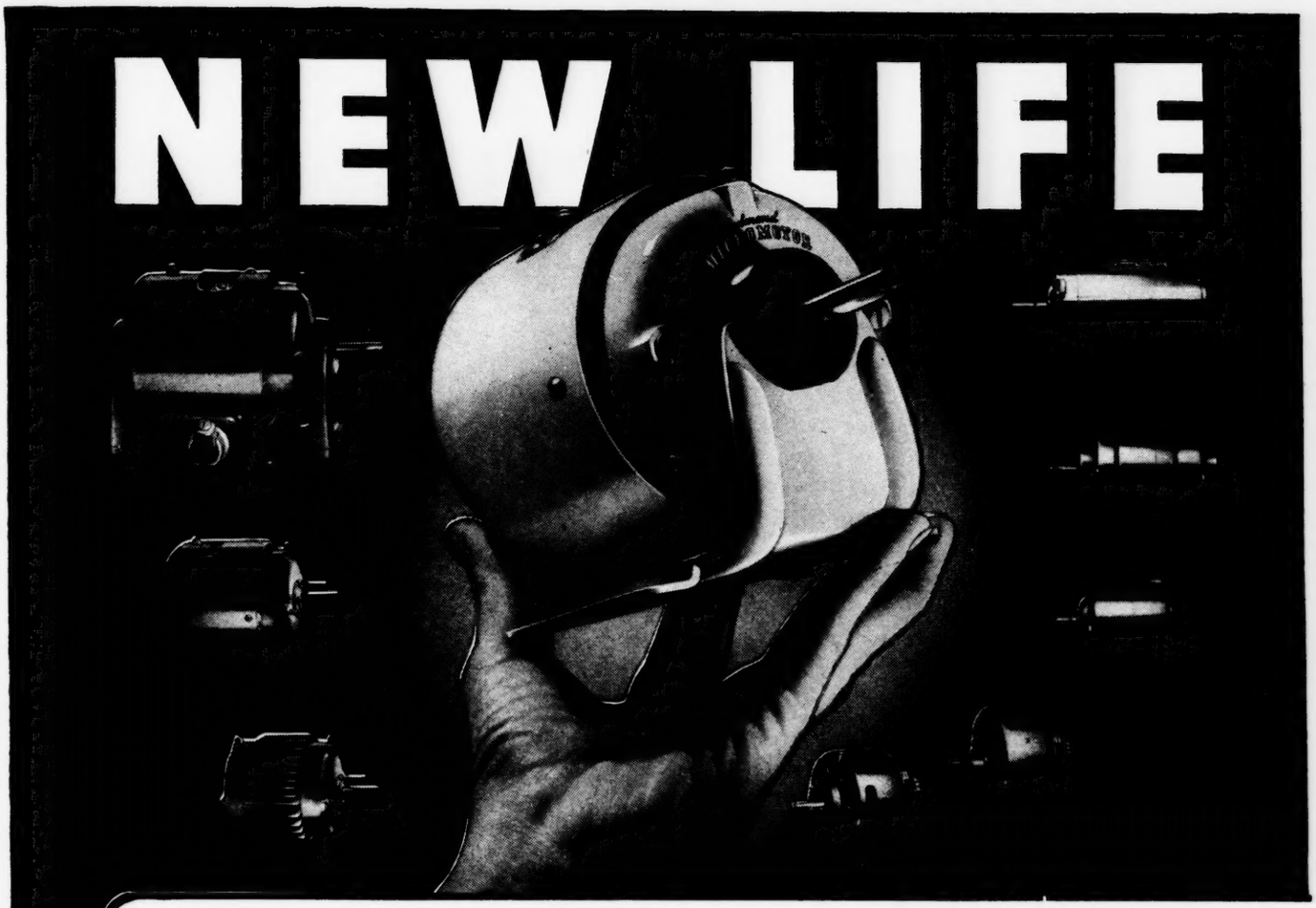
➧ For present production or post-war product planning . . . put Ellsworth's complete shop and engineering facilities to work for you now.

Write, phone or wire for details.

ELLSWORTH PIPE & SUPPLY CO.

1739 WEST ST. PAUL AVENUE MILWAUKEE 3, WISCONSIN

NEW LIFE



FOR YOUR POSTWAR PRODUCTS...
Redmond MICROMOTORS

ADD new life to your products with Redmond Micromotors, built in sizes up to a tenth horsepower.

Add the revealing touch of experience—accomplishment by specialists—the magic of precision on a mass production basis.

Get the exclusive Redmond patents and original Redmond developments. Take advantage of Redmond's 18 active years of effort concentrated on micro-power and its varied applications.

Learn all about these fine Micromotors, their long life, consistently low operating cost, and low first cost. *Write us today.*

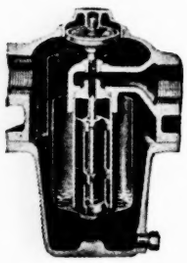
Shaded Pole AC Micromotors are built in sizes up to 1/20th horsepower. Series and Shunt Wound DC Micromotors are built in sizes up to 1/10th horsepower for operation at 6 to 115 volts. Micromotors can be tailor-made to meet unusual requirements.

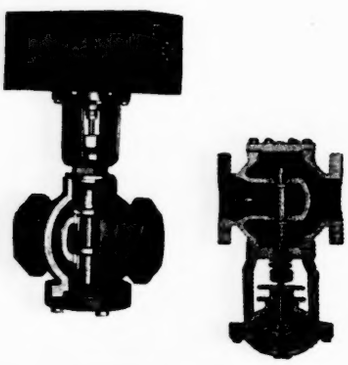
A. G. Redmond Company

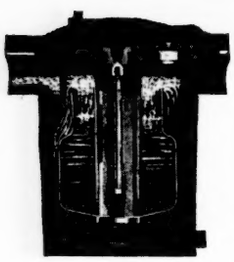
REDMOND KNOWS MOTORS
R
REDMOND

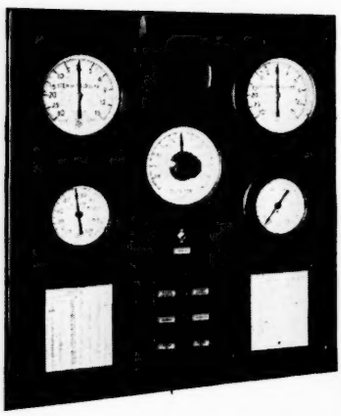
Composite sketch of Redmond facilities with over 5 acres of floor area.

OWOSSO, MICHIGAN, U. S. A:









Meet tomorrow's demands for heating comfort and fuel economy with

ILLINOIS

Automatic

Steam and Fluid Control Equipment

Demands for reconditioning, remodelling and new and better heating systems will be abnormally high when the restrictions of the past few years have been lifted. Prepare *Now*—Plan *Now* to meet these demands.

Illinois Control Equipment includes Combustion Control, Flow Control (electrical or pneumatic), Zone Control and a complete line of steam heating and power specialties for heating comfort and fuel saving and for industrial process control as well.

"ILLINOIS" is your logical, dependable source of supply for heating and power specialties that have been carefully engineered, thoroughly proved and have a performance record that is beyond question.

Our representative nearest you in our nation-wide service will give you full information.

Write for bulletins.

ILLINOIS ENGINEERING COMPANY
INCORPORATED 1900
RACINE AVENUE AT 21ST STREET • CHICAGO

A new idea in TRANE catalogs
to aid you in specifying . . .

TOMORROW'S HEATING AND AIR CONDITIONING NOW!

You Can Select Exactly What You Need From the World's Largest Line of Heating—Cooling—Air Conditioning—Air Handling Equipment From This One All-Inclusive Catalog

For that postwar building project you now have on the drawing boards, Trane provides a revolutionary new Products Catalog. Its 84 pages present a complete array of heating, cooling and air handling products. Products that will be ready the moment war restrictions are removed. Products that can be specified now. Products from the most complete line of its kind in the industry.

Before the new catalog was printed, Trane Engineers condensed capacity information—streamlined roughing-in dimensions—boiled down selection data to an absolute minimum—provided just enough tables, charts and details to correctly select the products illustrated.

You can specify the heating, cooling and air handling equipment for any postwar project. Everything that is required—the illustration of the product—the information to select the product—is contained in this one complete catalog.

Shortages and other wartime conditions make it necessary to restrict the distribution of this new catalog to those directly concerned with the selection, purchase and installation of heating, cooling, air handling and air conditioning equipment. Architects, engineers, contractors, industrial executives and maintenance engineers—in requesting your copy of the Trane Postwar Products Bulletin—please use your regular letterhead and say, "Send me my copy of PB290."

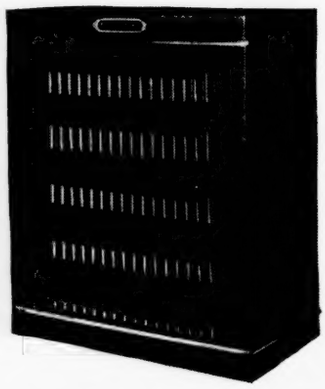
TRANE

THE TRANE COMPANY LA CROSSE, WISCONSIN

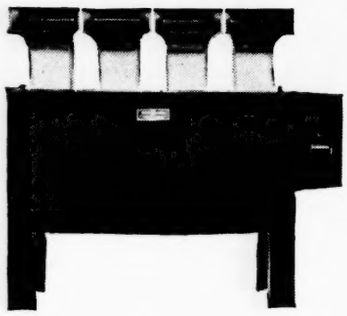
TRANE COMPANY OF CANADA, LTD., TORONTO

AIR CONDITIONING · · HEAT TRANSFER · · AIR HANDLING EQUIPMENT

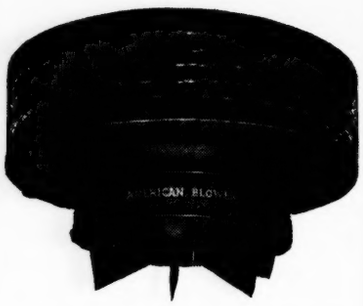
AMERICAN BLOWER
MECH. DRAFT · AIR-CONDITIONING
FLUID DRIVES · DUST COLLECTORS



American Blower Ventura-fin Unit Heater (Horizontal Type).



American Blower Sirocco Unit Heater (Blower Type).



American Blower Vertical Type Unit Heater.

ARMY E NAVY
For Excellence in Production

June in January

ALL WINTER LONG!

Yes, you can enjoy June in January and in every other month when heating is required, right in your own plant with American Blower Unit Heaters.

No hot spots or cold corners, but steady, healthful temperatures with heated air forced into working areas — where you want it — when you need it.

There are three types of American Blower Unit Heaters—Vertical Units for heating large, high-ceilinged industrial plants and other areas where heated air must be forced over wide spaces—Horizontal Type for wall or ceiling mountings in factories, plant offices, garages, warehouses, etc., where it is advisable to force heated air over wide areas at desired levels — and the Blower Type of Sirocco Unit Heater for ceiling applications or floor installations in large, hard-to-heat industrial plants, airplane hangars and shops.

Best of all, you can buy these units now with an order carrying a Priority Rating of AA-5 or better, with a specified delivery date.

American Blower Unit Heaters save you up to 20% or more in fuel consumption, and provide ideal working conditions.

AMERICAN BLOWER

AMERICAN BLOWER CORPORATION, DETROIT, MICHIGAN
CANADIAN SIROCCO COMPANY, LTD., WINDSOR, ONTARIO

Division of American Radiator & Standard Sanitary corporation

LINK-BELT Offers Distributors and Dealers an unusual opportunity. Let us explain this profitable Stoker Sales Franchise NOW!

LINK-BELT COMPANY

STOKER DIVISION, 2410 W. 18TH ST., CHICAGO 8, ILL.

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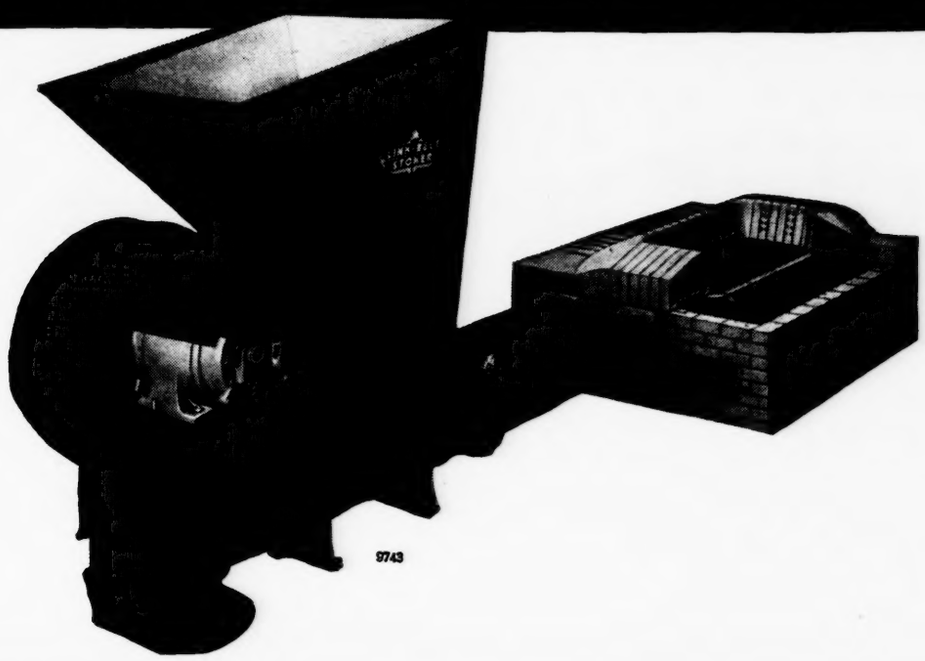
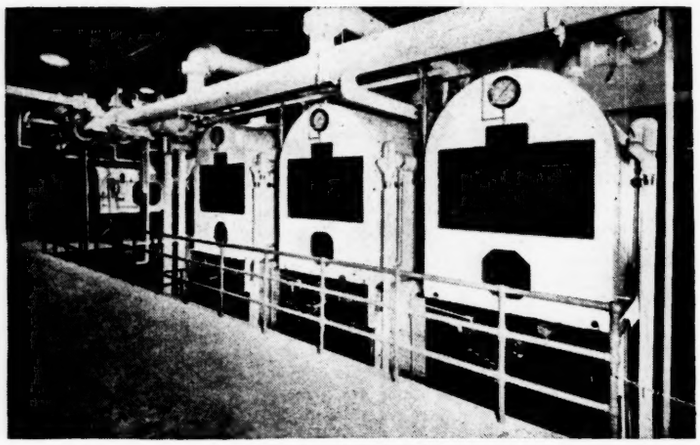
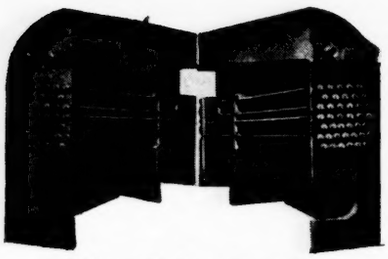
AUTOMATIC COAL STOKERS



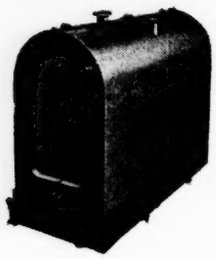
"FUEL-SAVER" BOILERS AVAILABLE AGAIN



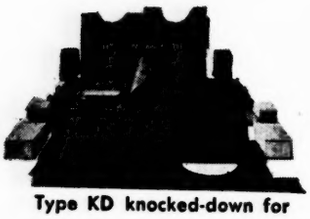
Typical Type C Installation.



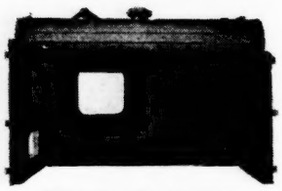
Halves of twin section boiler ready for bolting.



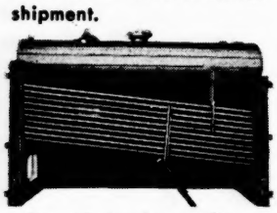
Bolted.



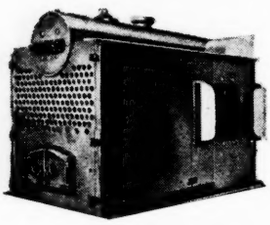
Type KD knocked-down for shipment.



First step in erection.



Second step in erection.



Erected in boiler room.

FOR years "Fuel-Saver" Boilers Type C have met the requirements for low cost heating in office and apartment buildings, hotels, schools, theatres, industrial plants, etc.

Their design and construction makes them especially suitable for post-war heating requirements:

QUICK STEAMING
Due to rapid and positive internal water circulation.

MAXIMUM HEAT ABSORPTION
Due to effective distribution of heated gases.

EASE OF CLEANING
Due to accessibility of heating surfaces.

"FUEL-SAVER" Boilers have cut fuel costs in thousands of heating installations.

Complete range of standard sizes rated in accordance with S. H. B. I.—15 lb. A. S. M. E. standard—for hand, stoker, oil or gas firing.

Type C twin section—a heating boiler in halves. For installation where Type C one piece cannot be carried through existing passages.

Type KD—knocked down—a heating boiler designed for shipment so that sections can be carried through a door or window. Eliminates expensive cutting or patching of building. Reduces time out when in need of steam.

Every International Representative is a competent boiler man able to assist in solving heating problems.

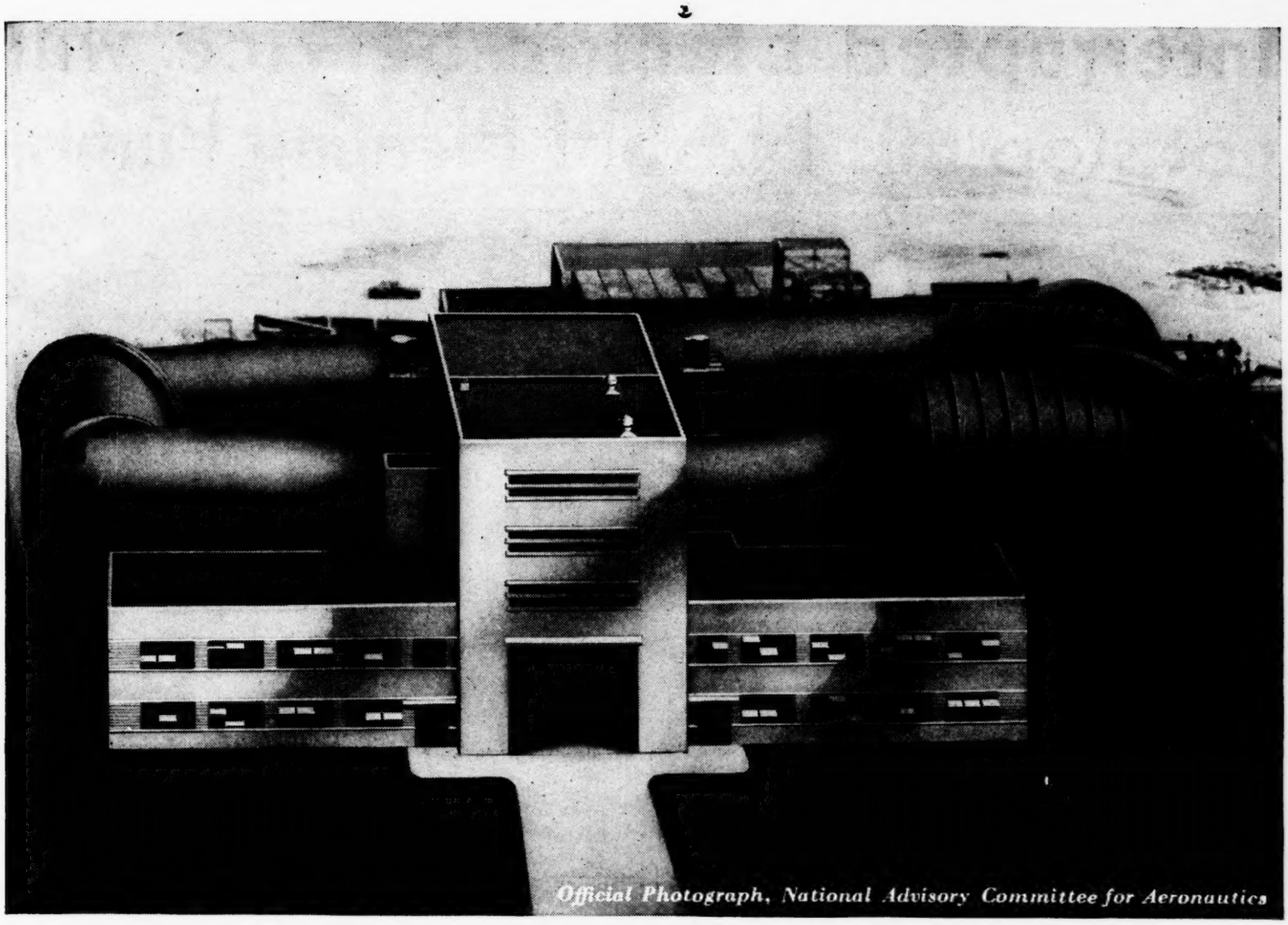
Write for bulletin describing Type C and Type KD boilers. See Sweet's Architectural File.

Boiler Builders for 58 Years

THE INTERNATIONAL BOILER WORKS CO.
HEATING DIVISION
310 BIRCH STREET • EAST STROUDSBURG, PA.

HEATING BOILERS TYPES C, KD, DD, K

POWER BOILERS TYPES CR, FR, LFR, LFS



Official Photograph, National Advisory Committee for Aeronautics

YOLOY AIDS JET PROPULSION RESEARCH IN FRIGID STRATOSPHERE HURRICANES

YOLOY steel forms the walls of a new sub-zero high-altitude wind tunnel at the engine research laboratory of the National Advisory Committee for Aeronautics, at Cleveland, Ohio. This is the only wind tunnel of its type in the world. Yoloy was selected for this job because of its high resistance to impact and its freedom from brittleness at very low temperatures.

This wind tunnel is already in use in advanced studies of jet propulsion engines and other critical development projects. In the tunnel, an 18,000 hp motor driving a 32½-foot fan generates a 500 m.p.h wind at a temperature of 48° below zero. The tunnel also duplicates the low pressures of high altitudes.

Yoloy is a high tensile, low carbon nickel-copper alloy steel. It is highly resistant to corrosion, is easy to machine and form and weld, and its unusual strength makes it ideal for structures and products where weight saving is important. Yoloy is available in plates, sheets, strip, shapes, wire, seamless and electric weld pipe.

This Yoloy-lined N.A.C.A. wind tunnel, only one of its kind in the world, produces the extremely low temperatures and pressures of the substratosphere, for testing and improving aircraft and engine performance.

YOUNGSTOWN

THE YOUNGSTOWN SHEET AND TUBE COMPANY

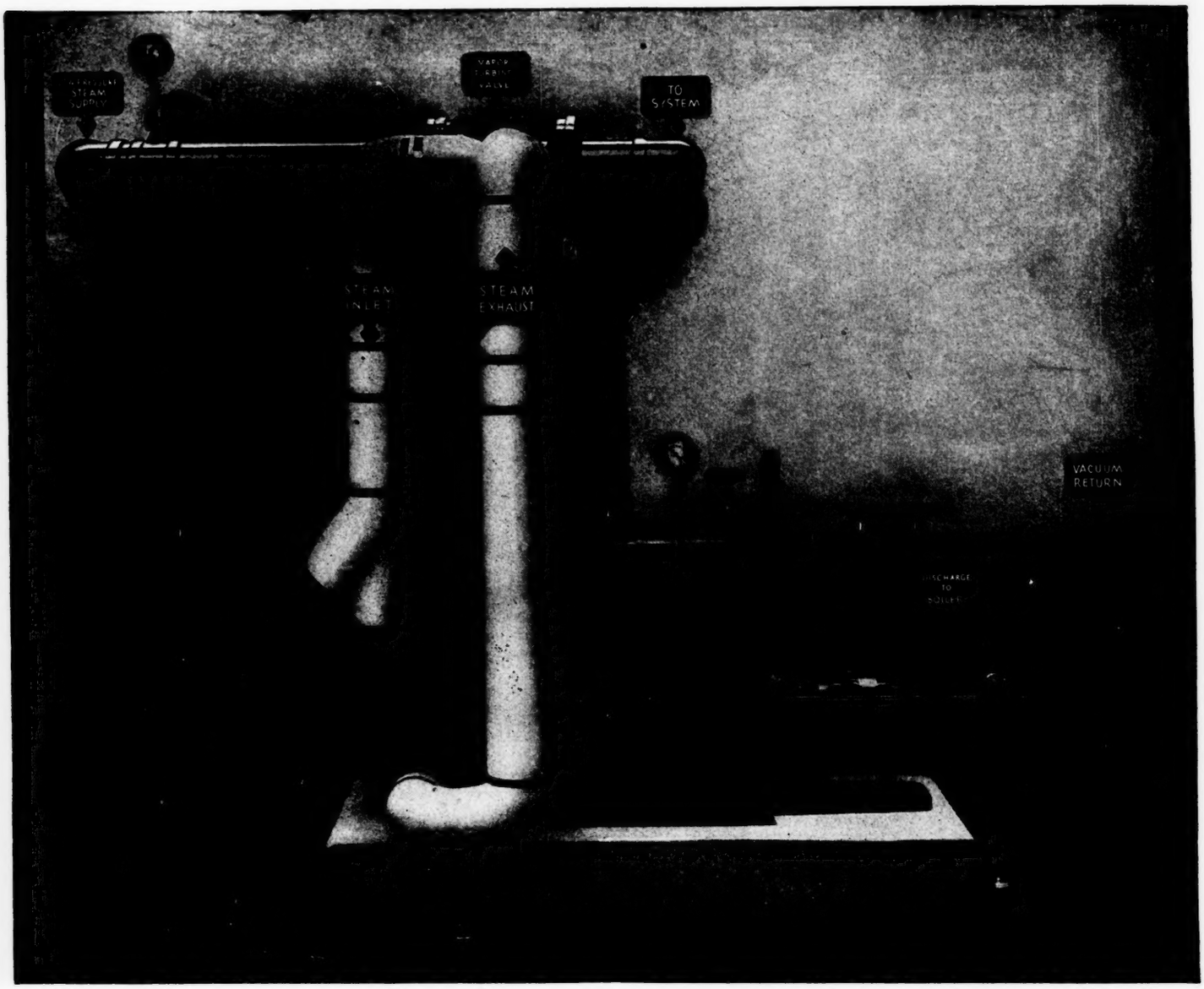
YOUNGSTOWN, OHIO

Manufacturers of

CARBON - ALLOY AND YOLOY STEELS

Pipe and Tubular Products - Sheets - Plates - Conduit - Bars - Electrolytic Tin Plate - Coke Tin Plate - Rods - Wire - Nails - Tie Plates and Spikes - Alloy and Yoloy Steels

Interrupted Electric Service will not stop this NASH Heating Pump!



In Hospitals, Greenhouses, Schools, Public Buildings, Theatres, wherever heating systems must not fail, install the Nash Vapor Turbine, for it is independent of electric current failure, and continues to operate as long as there is steam in the system.

This is because the prime motive power of this economical pump is a special steam turbine, controlled by a unique "Vapor Turbine Valve", which automatically bypasses from the heating main a small portion of steam, the exact amount necessary to develop the power needed to remove the condensate and maintain the required vacuum on the system. Even this small amount is passed immediately back to the mains, and goes on to the system with little heat loss. This pump operates on any system, high or low pressure.

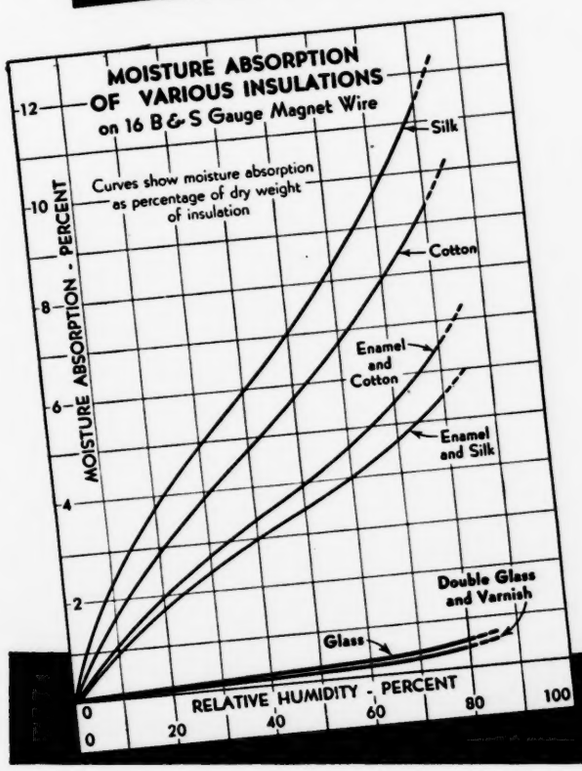
The Vapor Turbine is a most economical pump, for the elimination of electric current does away with current cost, the largest single item in the operation of an ordinary return line heating pump. Bulletin on request.

THE NASH ENGINEERING COMPANY

205-A WILSON ROAD, SOUTH NORWALK, CONNECTICUT, U. S. A.

MORE *Engineering* DATA on

BALDOR GLASS INSULATED MOTORS



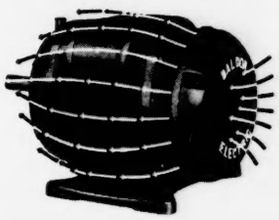
GLASS INSULATION

ASSURES LESS MOISTURE ABSORPTION AND HIGHER DIELECTRIC STRENGTH

As the individual glass fibers of BALDOR glass insulated motors are non-hygroscopic, the dielectric strength remains almost as high in humid or damp surroundings as in a dry atmosphere. Being inorganic, glass insulation does not rot nor deteriorate even when constantly exposed to dampness.

Furthermore, glass insulation withstands high temperatures and provides MORE horsepower in SMALLER frame sizes.

May we give you all the facts?



another BALDOR post-war feature

Baldor STREAMCOOLED DESIGN provides totally enclosed motors, externally cooled. A non-clogging ventilation system.

BALDOR ELECTRIC COMPANY, ST. LOUIS 10, MO.

District Offices in Principal Cities

PLAN YOUR POST-WAR MOTOR REQUIREMENTS *Now*
get the latest BALDOR Bulletins

DE-STA-CO
Blower Wheel Housings

of Standard Dimensions

Made in sizes to fit 4½, 5, 6, 7½ and 9 inch wheels and in widths to suit single or double inlet wheels . . . also individual parts for your own assembly.

De-Sta-Co housings are engineered for maximum efficiency and quietness in operation . . . neatly finished. Send for "De-Sta-Co Blower Housings" bulletin; gives complete information, including essential dimensions.

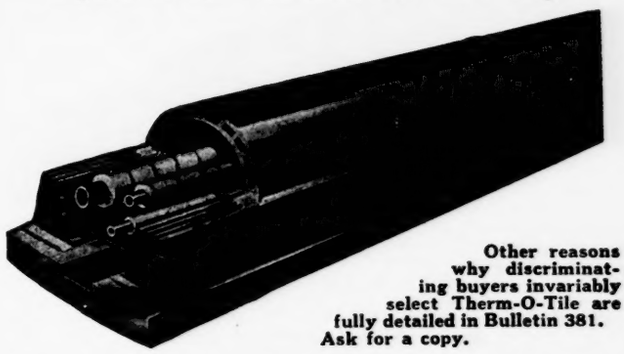
DETROIT STAMPING CO.
Established Over 25 Years
375 Midland Ave • Detroit 3, Mich.

??? DRY ??? INSULATION

That's a very important question.

Unless the insulation in underground steam conduits is really DRY, it is about as good as no insulation at all.

Therm-O-Tile assures DRY insulation —PERMANENTLY—*not* merely for a year or so. Bulletin 381 tells *why.*



Other reasons why discriminating buyers invariably select Therm-O-Tile are fully detailed in Bulletin 381. Ask for a copy.

Sold and installed by Johns-Manville Construction Units in all Principal Cities. See Sweet's Architectural Catalog or The Heating Guide.

H. W. PORTER & CO., Inc.
823-V Frelinghuysen Ave., Newark 5, New Jersey

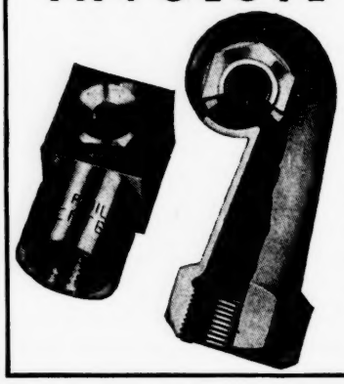
AUTEMPCO
MOTORIZED VALVES

INDOOR-OUTDOOR TEMPERATURE CONTROLS

Originators of Electronic Controls for Heating Systems

AUTEMPCO CORP., 521 Fifth Ave., New York 17, N. Y.

YARWAY
INVOLUTE NOZZLES



The preference for trouble-free air washing service — because there are no internal parts or vanes to wear or clog. Proven through many years of service in water cooling and air conditioning installations totaling more than 5 million g. p. m.

Made in sizes and types for all requirements. Ask for Bulletin N-616.

YARNALL-WARING CO.
104 Mermaid Ave. Phila. 18, Pa.

CLASSIFIED ADVERTISING

Non-display advertisements 10 cents a word per insertion. (No charge for name and address.) Minimum charge $2.00. Payable in advance.

Honeywell Needs Men

We have several openings for Sales Engineers and Installation men with experience in each of the following: domestic heating, commercial heating, refrigeration, air-conditioning. We also have openings for men with training in the above or similar work, or with suitable schooling but lacking experience. Men between the ages of 26 and 32 preferred.

Three months specialized training with pay. Excellent post-war possibilities. Send brief statement of education, experience, age, family, and salary desired to:

Minneapolis-Honeywell Regulator Co.

Office and Technical Personnel Division
Minneapolis 8, Minnesota.

ENGINEER AND ESTIMATOR—Age 37, married, 3rd Year University Undergraduate, School of Mechanical Engineering, 15 Years Experience on Installation, Contracting, Estimating and Design of Steam Power Plants, Steam Heating, Air Conditioning, Refrigeration, Ventilating, Plumbing and Water Supply Systems, Location preferably South Eastern or South Western States, but other locations very definitely considered. Address Box No. 409, HEATING AND VENTILATING, 148 Lafayette St., New York 13, N. Y.

MECHANICAL ENGINEER WANTED—Experienced in heating, ventilation, process piping and layouts. Graduate, between 28 and 40 years preferred. Position Assistant Engineer with old established company in Chicago Metropolitan area. Give age, education, previous experience. Box No. 408, HEATING AND VENTILATING, 148 Lafayette St., New York 13, N. Y.

MANUFACTURERS' DISTRIBUTOR—Long established in Philadelphia Metropolitan Area with complete sales and engineering facilities and large clientele—desires agencies with manufacturers of unit heaters, copper convectors, heating boilers and furnaces (all fuels), steam traps, radiator control valves and condensate pumps, circulators and flow-control valves. Box No. 405, HEATING AND VENTILATING, 148 Lafayette St., New York 13, N. Y.

GRADUATE MECHANICAL ENGINEER—With over five years experience in design, sales, and installation of heating, ventilating, refrigeration, and air conditioning systems and equipment, desires change to position of more reponsibility. Present salary $5,000 per year, age 30, draft exempt. Can arrange for release anytime after first of year. Box 410, HEATING AND VENTILATING, 148 Lafayette St., New York 13, N. Y.

DEGREE-DAY HANDBOOK

A handbook for checking heating plant operation and predicting fuel consumption. Supplies temperature reference data for winter and summer air conditioning operation and design calculations, including the practical application of degree-day tables. Forty-six actual examples from various types of buildings show the solutions of operating problems and also the use of the degree-day in sales or other promotional work.

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HEATING AND VENTILATING, 148 Lafayette St., New York 13

They're Going Overboard For Victory—Are YOU?

USE 8-POINT PLAN FOR AN OVERBOARD DRIVE IN THE 6th WAR LOAN!

NOV. 20th TO DEC. 16th

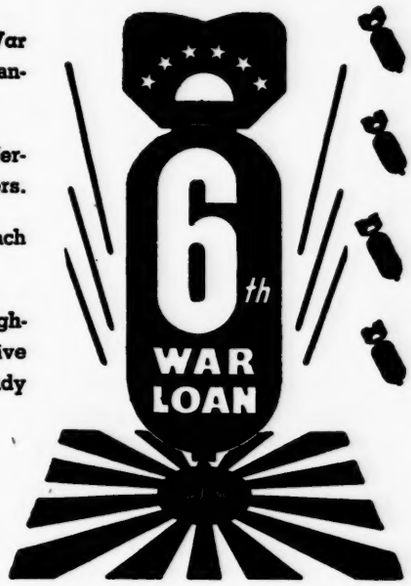
Our fighting men still have a long way to go! But—your plant-wide selling of the 6th can do much to shorten their embattled miles—lessen the price they so willingly pay for victory! Join the coast to coast parade of patriotic firms that are assuring an **"overboard" showing in the 6th** by following through on **every** point in the 8-Point Plan.

Start the ball rolling by appointing a **6th War Loan Bond Committee,** representing labor, management and other groups.

Carry on by selecting a **Team Captain**—preferably a returned veteran—for every 10 workers.

Right at the start, establish a **Quota** for each department—and every employee.

Arrange frequent **Meetings of Captains,** highlighting importance of their work—effective sales methods—and need for painstaking study of Treasury Booklet, Getting The Order.



Make definite **Assignments** to those best equipped to arrange music, speeches, rallies, competitive progress boards and meeting schedules.

Issue Individual Pledge Cards—made out in the name of each worker and providing for both cash and installment purchase.

Resolicit! This is the secret of "overboard" War Bond subscriptions. Your State Payroll Chairman has a special Resolicitation Plan for you to put into action near the end of the campaign.

Give generously of your **Advertising Space** to drive home the War Bond story.

The Treasury Department acknowledges with appreciation the publication of this message by

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It is packed under full steam pressure. By the turn of a wrench, integral pressure guns force a special semi-plastic packing into the stuffing box.

Welded Steel Construction. Alemite lubricated cylinder-guided sleeve. Made also in conventional gland-pakt types. Write for Bulletin EJ-1908.

YARNALL-WARING COMPANY
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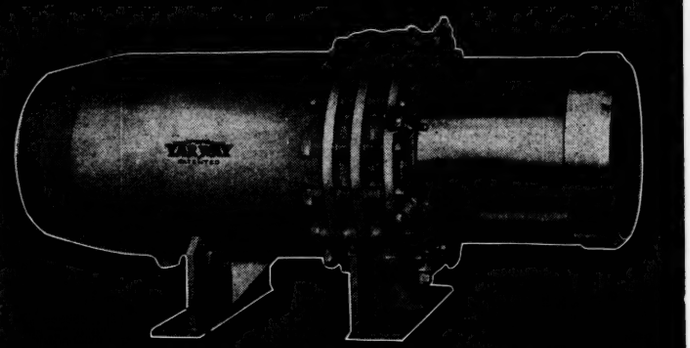

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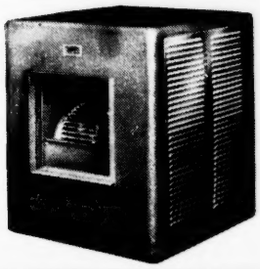

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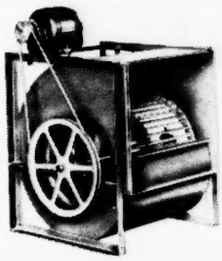

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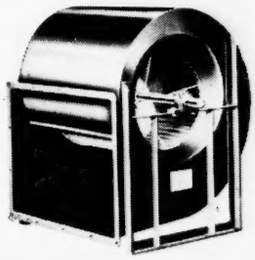

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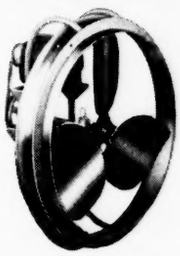

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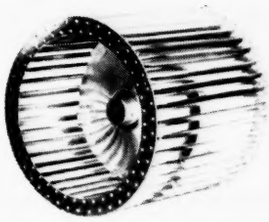

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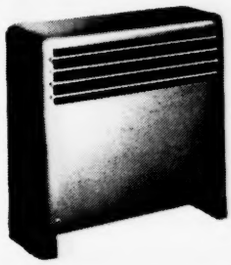

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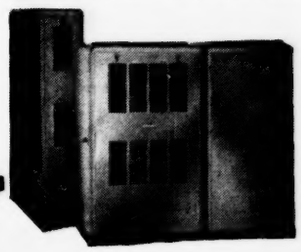

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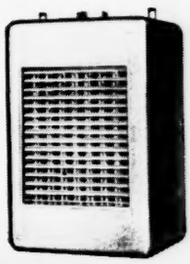

AVAILABLE NOW

Utility Standard and Heavy Duty Blowers, Evaporative Air Coolers, Industrial Exhausters and Propeller Fans are now available under WPB regulations and priorities. Gas-fired heating equipment will be available when war restrictions are lifted to permit manufacture. Illustrated literature, catalogs of performance data and details of Utility's marketing plan are available on request.

UTILITY

FAN CORPORATION

4851 S. Alameda Street

Los Angeles, California

Munitions plus . . .

These stanzas were written under fire, "Somewhere in Italy," by Major Earl J. Rice, Field Artillery, United States Army, on leave from the Engineering Department of the Johnson Service Company.

REFLECTIONS FROM THE FRONT

Do production problems bother you
And schedules get you sore?
Your muscles ache; you think you're thru,
And the boss asks you for more!

And, at the end of daily grind,
Are there some provocations?
A crowded bus or car, you find,
To reach your destinations?

Now dwell a while with me, old friend,
To banish all your woe.
By censor's grace, to you I'll send
A word from G.I. Joe.

I've seen our boys up in the line,
In several foreign lands,
With weapons that were super fine—
Produced by skillful hands.

And every time we send a shell
To knock off "Jerry's" dome,
We thank the Lord—and very well—
For production lines back home.

For "Jerry" has some things to pour—
Bullets, shells, and flak.
But thru your efforts, we have more
That we can hand him back!

MEN at the Front need more than munitions to win decisively. And it is up to every one of us to meet these needs, every hour of every day. In this way, Victory will be ours . . . sooner.

Whether employed in a war plant or not, each of us—at work or at play—is an important part of a production line; each building morale wherever he is.

An encouraging word, a pat on the back, no complaints about wartime inconveniences, a letter to a soldier, the purchase of more war bonds . . . these are the important things that give our fighters greater stamina for the knock-out blow.

• • •

Johnson Service Company, in addition to its normal activity of manufacturing and installing temperature control equipment, much of which goes into war plants, is proud to be making a variety of special items necessary to the war effort.

JOHNSON

Fuel-Saving Starts With CONTROL

Automatic TEMPERATURE AND AIR CONDITIONING *Control*

JOHNSON SERVICE COMPANY, MILWAUKEE 2, WISCONSIN • DIRECT BRANCHES IN ALL PRINCIPAL CITIES